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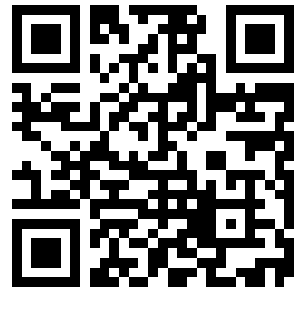

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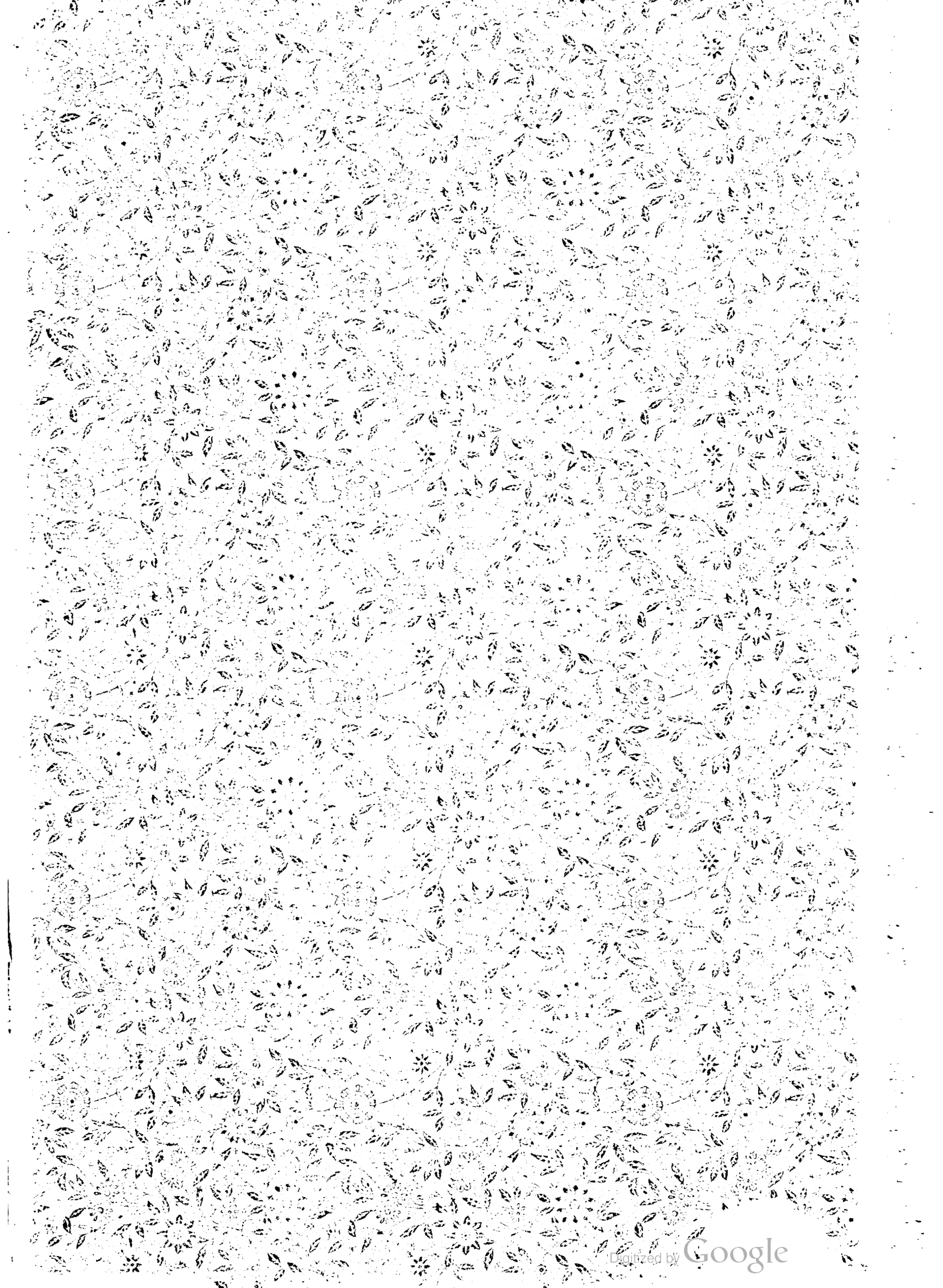
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THE ELECTRICIAN:

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NOTES.

The elaborate system of examination which has hitherto been a prominent feature of the German Patent Office has not only put an end to many attempts to obtain protection, but has effectually prevented the introduction of inventions into that country, since it is not worth while to do business in most cases unless under a patent. The modification of this system, on which Mr. Chapman gives some information in our correspondence columns, seems likely to reduce the annoyance to which inventors have been subjected, and, no doubt, it will in future be worth while to appeal against the decisions which hitherto were practically final. A more important step is the introduction of an altogether new patent system, which appears to be intended to encourage the patenting of small inventions. The process of application is as simple as in this country. No examination is made, no guarantee is given; the duration is only six years, it is true, but our own Patent Office records show how small is the proportion of patents kept up for any longer period. We understand that a model or sample of the invention should be submitted, if possible.

The experiments on electrical discharge which Prof. J. J. Thomson describes in this issue will be found both interesting and instructive. They have been carried out by one of our leading mathematicians, yet no resort is made to symbolic language, and the reasoning adopted will be found clear and straightforward. The work is, therefore, especially valuable, for a research on a subject of this kind is apt to waste itself in a number of pretty but disconnected experiments. Apparently, Prof. Thomson has conclusively proved two important assertions, the truth of which has at times been questioned: namely, that a vacuum is a perfect insulator, and that a piece of iron behaves like a magnetic substance when submitted to magnetising forces alternating with great rapidity. The research is also highly instructive with reference to the probable electrolytic character of all electric discharges through gases. The experiments on the electric glow in gases are in some respects comparable with those made by Mr. Tesla with alternate currents of high frequency. In many ways a glow lamp consisting of a mass of electrically excited gas is an ideal source of light. Its efficiency is many times as great as that of an ordinary glow lamp, while the large amount of luminous surface is also a great point in its favour. Its practical use is, however, problematical, owing to the difficulties attending the production of currents of the requisite frequency, and in transmitting energy by their means with any reasonable efficiency.

One of the minor blessings of the electric light, which, though not so scientific as the absence of carbonic acid, is as distinct an economy as the absence of smoke. We refer to the use of the glow lamp in shop windows, instead of the outside gas lamps, which do so much damage to hats. The first London shops to adopt the electric light were those in Bond-street. To the demands of the Bond-street shopkeepers, in fact, is due the development of the Grosvenor Gallery into a central station; and to them the largest station in the world may be said to owe its existence.

We may naturally turn to the Bond-street windows to learn how the glow lamp may be employed for displaying the best goods in the best manner. In more than one shop we find no shades, and the eye is dazzled by the lamp. In one or two the primitive cone of folded paper is to be found. The lighting of several large windows, containing pictures and statuary, is well managed in a theatrical manner, the lamps being hidden at the sides or above. Next to one of these windows is a shop in which shades are used; but considering the excellent opportunity which is afforded for artistic treatment in such a case, we cannot admire the combination of a china saucer and a coat-hook which is attached to the lamps. The saucer is a shade, the coat-hook is not used to display the wares, but consists of a bit of wire and a brass knob, and acts as a counterpoise to the weight of the saucer. In the next window, where nothing more artistic than portmanteaus are to be seen, some particularly beautiful shades are to be found. They are nothing more than large shells, riveted to a brass support. They are large enough to completely hide the lamp from direct view, but the light shines through the translucent shells, and exhibits their natural colours in a very effective manner.

A letter from Messrs. O. Berend and Co. will be found in the correspondence columns of this issue, in which they challenge the comments made by us last week. They send us also a catalogue containing complete descriptions and many illustrations of Hartmann and Braun's electrical instruments. With reference to our criticism, we notice on p. 5 that the core of the Kohlrausch ammeter has a travel of about four inches. "The scale can be spread out in any desired region by various forms of cores specially worked out." We find that these instruments

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"are no longer kept in stock for large currents on account of the increased popularity of the alarm clock form of instruments. They are made chiefly for the Recording ampere-meter." But we find a special note to the following effect:—"The scale commences to read at about 10 per cent. of the highest reading." This fully substantiates our criticism; and though the scale can no doubt be spread out in most regions, we should like to see an instrument of this kind in which the first 10 per cent. will be so spread that the whole scale may be uniform. This, we believe, is not possible to produce with a core and a spring, but it might be done with complicated empirically-shaped cams. We therefore still fail to see that this recording instrument can be used for measurements of areas. The illustrations of the straight scales, which will also be found in our correspondence columns, fully confirm our remarks.

We observe that the Hartmann and Braun voltmeters "have a solenoid with a short moving core which, when magnetised, arranges itself in a line with two fixed cores, so as to make a more continuous iron path for the induction. The cores are made of very light soft sheet iron. The movement is opposed by gravity, and the cores are so shaped as to secure large reading near normal pressures." This is an excellent way of making a voltmeter, but surely this is not one of the "new instruments which have not previously been brought before English electricians." We notice in the preface that Messrs. Hartmann and Braun are "always grateful for any suggestions that may occur to the skilled electrician" who uses their instruments. They ought to be particularly grateful to Mr. Evershed for this gravity voltmeter, but perhaps these instruments are not intended for sale in this country. The catalogue from which we have quoted contains a large number of very elaborate scientific apparatus for laboratory work, besides the numerous engine-room instruments, and, for the ground covered, is the most complete instrument catalogue we have seen.

Rumours have reached us that our leading article of last week on motors was about to be demolished, the arguments refuted, and that we should be generally humbled. We have heard that a gas engine costs 5d. an hour, and not 1d., and that three hundred cheap American motors have been sold in London already. Some criticisms would have been very welcome, but none have come to hand. Still more welcome would have been a list of those trades which find it economical to use electric motors on a supply company's service. The advantage of motors for intermittent use is manifest, and was alluded to repeatedly in our article. We ventured to draw the line at present at a four-horse motor running nine hours a day. With intermittent use of a gas engine it is, of course, impossible to maintain a consumption of 25 to 30 cubic feet per horse-power hour; and there will, therefore, be a point at which it becomes possible to use a motor with economy to say nothing of convenience. In determining this point, the greater first cost of a gas engine and its fixing must be taken into account. It is this point which we are anxious to discover, and on which no information has yet been published.

The description of the Van Depoele reciprocating drill by our Frankfort correspondent will be read with interest by those of our readers who have attacked the most difficult problem of constructing an efficient reciprocating motor. The idea of supplying a pulsating current is a great advance upon the use of a commutator forming part of the drill, since sparking is entirely absent and the circuit remains closed. Our correspondent says nothing about the sparking which might reasonably be expected at the commutator of the dynamo. The Thomson-Houston Company are probably equal to the occasion with some such heroic device as an air-blast.

Electric Traction at Brecon.—The Brecon Town Council have decided to take immediate steps for the formation of an electric railway to the Beacons.

Japanese Land Telegraph Lines.—The Japanese land lines, which were interrupted beyond Hiogo and Osaka on Oct. 28th, owing to an earthquake, have now been restored.

Blankenburg.—The whole of the streets of this town were lighted by electricity for the first time on October 19th. The work was carried out by Naglo Brothers, of Berlin.

Litho-Carbon.—A new material, known as litho-carbon, of which enormous deposits have been discovered in Texas, has, says *Industries*, been found to be a most excellent material for insulation.

Electric Light Inspector.—Mr. Arthur Edward Rossiter has been appointed, out of 57 applicants, to act as inspector of electric lighting for the London County Council, at a salary of £200 a year.

Presentation.—Last week the staff of the Bath Central Lighting Station made a presentation to Mr. B. Deakin, who is vacating his post there to take charge of the Brush Company's City station.

Electric Traction in Mexico.—Work has just been commenced on a new railway from Niño Perdido to Coyoacan and the Pedreral Quarries, Mexico, on which it is contemplated to employ electricity.

The Thirtieth Anniversary of the Telephone.—Thirty years ago, on the 26th October, 1861, Philip Reis showed his telephone in public for the first time to the members of the Physical Society of Frankfort.

Stuttgart.—The town of Stuttgart has purchased water power on the river Neckar at Marbach (some 15 miles distant), for £13,500. This power is to be used for running the electric lighting central station being built by the Municipality.

The Preparation of Pure Hydrogen.—Bertholet recommends for the preparation of pure hydrogen the electrolysis of water; then passing the hydrogen so obtained through a solution of permanganate of potash and drying it by means of fused caustic potash.

Electric Launches on the Spree.—Plans have been submitted to the municipal authorities of Berlin for a service of electric launches for passenger traffic on the River Spree. The project is being favourably considered by the Municipal Council.

The Water-Power of Switzerland.—M. Robert Lauterbourg, of Berne, has been studying the subject of the water-power available in Switzerland for electric lighting or electric power transmission. He concludes that 600,000 effective horse-power can be obtained without difficulty.

Tampering with Electric Light Wires.—During the recent "Lohengrin" disturbances in Paris several rioters were lodged for security in the ground floor of the Opera House. There they found something amusing to occupy themselves with. They set themselves to tamper with the electric light wires, which happened to be within their reach, and promptly started a short circuit.

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Telephone Litigation in the States.—The American Bell Telephone Company has brought a suit against the Metropolitan Telephone and Telegraph Company of New York, in the United States Circuit Court, to prevent the use or sale of telephones embodying the Bell patents.

The Power Station of the Boston West End Street Railway.—Some twenty pages of the *Electrical Engineer* of New York, of October 21, are devoted to an exhaustive account of the huge power station of the West End Street Railway, of Boston, now approaching completion.

Bristol University College: Engineering Society.—The members of this society made an excursion to Taunton last week, in order to inspect the electric light station and the Electrical Exhibition. The electrical works of the Newton Electrical Company were also visited.

Hammersmith Vestry.—At the last meeting of this vestry the clerk intimated the receipt of a letter from the secretary of the Putney and Hammersmith Electric Light and Power Supply Company, applying for the consent of the Vestry to the application of that Company for a Provisional Order.

Altenmarkt.—According to the *Elektrotechnisches Echo*, a company is in process of formation, with a capital of £50,000, for the purpose of deriving 9,000 H.P. from the rivers Alz and Argen and lighting the neighbouring towns of Traunstein, Trostberg, Burghausen, Simbach Laufen, &c., by electricity.

The Niagara Falls Power Tunnel.—The Niagara Falls power tunnel, which was commenced on October 4, 1890, is making rapid progress. The *Niagara Falls Gazette* says a total of 2,187ft. has been finished out of 6,530ft., and it is estimated that the tunnel to the canal will be completed by the middle of February next.

Large Belts for an Electric Power Station.—It is stated that the two largest driving belts ever made in the United States are now being manufactured in St. Louis for an electric power station. They are of three thicknesses of leather, each 72in. wide and 150ft. long. They weigh about 1,800lb. each, and each belt contains about 200 tanned hides.

A Telephonic Experiment.—On the occasion of a recent bazaar at Bootle a somewhat novel experiment was made in connection with the phonograph and the telephone. The Liverpool exchange was connected to the bazaar, the phonograph installed there being placed in direct communication with the telephone receiver. A song sung at Liverpool was then recorded on the phonograph. This was next successfully transmitted back to Liverpool from the bazaar.

The Cost of Horse Haulage.—In the prospectus just issued by the South-Eastern Metropolitan Tramway Company it is stated that the Company have entered into a contract for 21 years, terminable by the Company by notice after seven years if the Company desire to work the tramway by mechanical power, with the well-known firm of Thomas Tilling, for horsing the cars at a fixed price of 6¼d. per mile, with a minimum daily run per car of 60 miles.

Central Station Revenue in Paris.—The average gross central station receipts per month of the Compagnie Continentale Edison since its inception in August, 1889, have been £5,580. The minimum monthly revenue was that of July, 1890, which amounted to only £3,102; the maximum of £8,448 occurred in February of the present year. The gross receipts for the whole of 1890 amounted to nearly £63,000, and to over £40,000 for the first six months of the present year.

A New Electrical Machine.—At a recent lecture M. Henri Becquerel exhibited an ingenious frictional electrical machine, devised by his demonstrator, M. Peignot. Mecrury is forced by means of a pump through the pores of a piece of chamois leather, and electricity in considerable quantities is generated by the friction. Ducretet, the well-known Paris instrument maker, has just finished a machine of this kind for the Conservatoire. The column of mercury is 1 metre high and 30 centimetres in diameter.

Prof. von Helmholtz.—Prof. von Helmholtz celebrated his 70th birthday on Monday. He was the recipient of numerous addresses and presents from learned societies in all parts of Germany. The congratulations of the Government were presented by the Minister of Public Worship. The University of Berlin was represented by the Rector, Prof. Förster; and the learned societies of London, Paris, Stockholm, Rome, Turin, Berne, and Vienna also sent their congratulations. In the evening a banquet took place in the Kaiserhof Hotel, which was attended by over 500 guests.

The Paris Municipal Station.—For some time past there have been vigorous complaints with regard to the irregularity of the current supply from and bad sanitary condition of the Paris Municipality's Central Station at the Halles. After several interpellations on the subject, the Conseil Municipal last week voted £640 towards improving the ventilation of the station. With regard to the irregular supply, it seems that the dynamos are overloaded, and accumulators are needed to cope with the demand for current during the busy hours. Meanwhile no more customers are to be connected up.

Lighting Circuits on Electric Railways.—The Cleveland Electric Railway Company is prepared to do electric lighting, and is negotiating with the municipal authorities for the illumination of the 50 miles of streets through which their lines run. "It seems to us," says the *Electrical Engineer* of New York, referring to this new development, "that in many cases the undertaking of street lighting service will enable the railway companies not only to keep more cars going, but to operate all around the clock. Thus, with a service to stationary motors during the day, and to arc lamps at night, the Electric Railway Company will see the curve of its load diagram flattened out at a high level of amperes with an exhilarating increase in the margin of profit."

Chicago Exhibition.—The Committee of the Polytechnic Institution (Regent-street) are arranging for co-operative excursions to the Chicago Exhibition in 1893, specially intended for working men and others whose means will not permit of visiting the New World under ordinary circumstances. The authorities have already entered into a contract with the Inman Steamship Company, by which means those who participate in these excursions will travel by the fastest vessels afloat; parties will leave Liverpool weekly during the months of June, July, and early part of August. The whole tour will be accomplished within one month. The Committee hope that the whole round excursion, including accommodation for the period, will not exceed 25 guineas. Already over half the places have been applied for.

The Electric Railway from a Sociological Point of View.—In a Paper recently read before the Thomson Scientific Club Lynn (Mass.), Mr. Oscar T. Crosby indulged in a good deal of statistic weaving. Assuming that the 33,700 electric cars now running in the United States make 490,000,000 miles per annum, and taking the economy to be four cents per car mile, Mr. Crosby estimates that society saves $19,600,000 per annum. He further estimates that there are 115,000 street railway stockholders in the United States, affected favourably in their incomes, ways of life, and ability to promote enterprises, by the higher returns from electric roads. To make the car mileage above mentioned there must be burned about 900,000 tons of coal. In all, some 80,000 individuals will, according to Mr. Crosby, be diverted within the next decade from their present occupations to those connected with electric railway work.

The Proposed Waterloo Station-Mansion House Subway.—In connection with this proposed electric subway railway, *Herapath's Railway Journal* states that about ten years back notices were given for two new independent lines from Waterloo into the City. The South-Western Company's engineer, Mr. Jacomb, then estimated roughly the cost of one of the projected lines at about £800,000 for construction and £1,500,000 for property. The cost of the proposed electric subway will not exceed £500,000. It is not proposed to slavishly follow the features of the City and South London Railway. The traffic from Waterloo to the City is purely for business men, and the time occupied would be about four minutes, with no intermediate stations. The promoters expect that they will come out within a few yards of the terminus of the Central London Railway which was authorised last year. A short subway would connect the two.

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Annual Dinner of the Institution of Electrical Engineers.—We are informed by the secretary that amongst the guests who have accepted invitations to be present at the dinner are—The Postmaster-General (Sir J. Ferguson, Bart.), the Inspector-General of Fortifications (Major-General Grant), Sir G. G. Stokes, Bart., M.P. (late P.R.S.); Sir John Pender, Sir Thomas Blomefield (Board of Trade), Captain W. J. L. Wharton, R.N. (Hydrographer to the Admiralty); the Presidents of the following societies: the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Iron and Steel Institute; Mr. Harrison Hayter, Mr. Alfred Giles, Sir Benjamin Baker, Dr. William Pole, Colonel W. Haywood (Engineer to the Commissioners of Sewers), and Mr. H. J. Chaney (Standards Department, Board of Trade).

Old Students' Association.—The seventh annual dinner of this Association was held on Saturday evening last at the Holborn Restaurant, under the presidency of Mr. W. B. Esson, some 60 members and their friends being present. The toast of "The Colleges of the City and Guilds of London Institute" was proposed by Mr. L. B. Atkinson, Dr. W. E. Sumpner responding. Mr. Albion T. Snell proposed "The Professors"; and in response to this toast Prof. Silvanus Thompson made an interesting speech, detailing the growth of the Institute since its inception. In the course of the proceedings the President announced that the ballot of members had resulted in his re-election; and that Mr. E. B. Vignoles had been awarded the Association medal for his Paper entitled, "Some Researches in Electro-magnetic Induction." Prof. Perry, owing to illness, and Mr. W. H. Preece, owing to another pressing engagement, were unable to be present.

Society of Arts.—The arrangements for the meetings of this Society during the ensuing Session have just been announced. The first meeting will be held on Wednesday, November 18th, when the opening address will be delivered by the Attorney-General, Chairman of the Council. On the following Wednesday evenings previous to Christmas Papers will be read on "The Measurement of Lenses," by Prof. Silvanus P. Thompson; on "The World's Fair at Chicago in 1893," by Mr. James Dredge; on "Secondary Batteries," by Mr. G. H. Robertson; and on "Spontaneous Ignition of Coal and its Prevention," by Prof. Vivian Lewes. Among the Cantor courses are lectures on "Electrical Distribution," by Prof. Forbes; and "The Uses of Petroleum in Prime Movers," by Prof. W. Robinson. A special course of lectures has also been arranged, under the Howard bequest, on "The Development and Transmission of Power from Central Stations," by Prof. W. Cawthorne Unwin, F.R.S., commencing shortly after Christmas.

Conventional Electricity.—There are, says *Industries*, many curious ideas which linger in the academic mind, and will, it is to be feared, never be eradicated. For instance, probably nine-tenths of the writers of text-books appear to think that electrical engineers use sine and tangent galvanometers for measuring, let us say, dynamo currents. Another established idea is that dynamos have something called a "critical speed," and that dynamo makers experiment to determine it. We have known makers turn out dynamos by the hundred without knowing what a critical speed may be. Of course we do not pretend to know either. Again, makers have worked for years to design voltmeters and ampere meters to give proportional readings. It is needless to remark that voltmeters should have their scales spread out near the standard pressures, while ampere meters should have similar scales for some purposes, and logarithmic scales for others. No instrument has yet been designed to give a logarithmic scale. The back electromotive force of the arc is now an old-established and eminently respectable phenomenon. Yet an electro-chemical pressure of thirty odd (very odd) volts is extreme, and there is no evidence to show that the conductivity of the arc does not vary as the cross section, and approximately as the current.

Obituary.—We regret to announce the death of Mr. William Fereday Bottomley. He commenced his career some 37 years ago in the service of the old Magnetic Telegraph Company. On the purchase of the telegraphs by the Government he joined the telegraph staff of the Lancashire and Yorkshire Railway Company with the late Mr. Warburton. Subsequently he undertook the management of the Manchester district for the Indo-European Company, which position he afterwards resigned to become one of the pioneers of practical telephony, and it was under his supervision that probably the first telephonic trunk lines in this country were erected. These were between Manchester and Stockport and Manchester and Oldham, and in this connection it is interesting to note that in these lines the now well-known "twisted wire" system, of which Mr. Bottomley, the late Mr. Charles Moseley, and Mr. W. E. Heys were the joint patentees, was first employed. As manager for Mr. Moseley, Mr. Bottomley, by his pleasant persuasions and by interesting public lectures, popularised the telephone in his district at an early date, and made the success of a telephone exchange which Mr. Moseley was about to establish a foregone conclusion. Mr. Bottomley next joined the National Telephone Company as their London Superintendent, but a few months afterwards the resignation of Mr. Butterworth having left the management of the Dublin Telephone Exchange vacant, Mr. Bottomley was appointed to the office, which he held and filled with great success until his death. At the commencement of his career he quickly gained the confidence of his chiefs, and being one of the most expert operators of his day, he easily won his way upwards; and it is highly probable that had he the high educational advantages which some of his colleagues possessed, his sound judgment, energy, and genial manner would have won for him a still more distinguished place. Mr. Bottomley died at the comparatively early age of 51, and leaves a widow and several children.

Effect of the Electric Light on Plants.—The results of some experiments on the influence of the electric arc lamps on plants in hothouses have been published by the authorities of the Cornell University Agricultural Experiment Station. The experiments were carried on during the winter of 1889-90, by introducing an ordinary arc of nominal 2,000 c.p. lamp into a house set apart for the purpose. This house was 60ft. long and 20ft. wide, and was divided into two equal portions by wooden partitions, so that one half might be kept dark during the night, while the other enjoyed sunlight during the day, and was kept lighted by the electric lamp at night. The electric lamp was suspended from the ridge of the house, just 2½ft. above the soil of one of four benches just below it. During the first six weeks commencing January 23, 1890, the light was naked, but during the rest of the time up to April 12th it was covered by an ordinary white opal globe. While the light was kept naked it showed a marked influence in hastening the maturity of such leaf plants as endive, spinach, cress, and lettuce. This was the more marked the nearer they were to the light, and the leaves were small and more or less curled or injured close to it. Notwithstanding this, they contained the same amount of starch as leaves of plants at a greater distance from the light, but the grains were larger and better developed. The result was that the plants ran to seed without forming leaves large enough to be useful for table purposes. The other division of the house, lighted by sunshine only during the day, was planted at the same time for comparison with that under the influence of the electric light. Within 3ft. of the lamp on either side the plants were killed outright, while all the rest were seriously crippled in the lighted house. Peas were most fruitful in the dark house, lettuce was fifty per cent. better at the end of three weeks in the light house than in the other, and was fit to cut in a month, while that in the dark house took a fortnight longer to grow to the same size. The colours of various tulips were intensified, but faded again in the course of four or five days. Varieties of coleus gave rise to some interesting facts. After two nights, within 3ft. of the lamp, the red sorts became yellow, brown became green, green lost its brightness, and dark purple became glossy-black. The shaded portions of the leaves remained unchanged, so that with daylight the exact outline of the shaded portion could be easily defined for some days afterwards. So varied have been the results with different plants under different conditions, that it is evident many more experiments must be made before any definite conclusion can be arrived at, as to whether the electric light can be put to any practicable and useful purpose with profit. This will form the object of future experiments which are to be undertaken.

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MAGNETISM IN IRON AND OTHER METALS.*—LV.

BY PROF. J. A. EWING, F.R.S.

(*Concluded from page 685, Vol. XXVII.*)

§ 187. **Effects of Elastic Strain.** — In previous articles (§§ 120—142) an account has been given of experiments made to investigate the effects of stress on the magnetic quality of iron and the other magnetic metals. Without attempting any full discussion of these results from the point of view which the molecular theory affords, we may refer to one or two general features where a molecular explanation seems comparatively easy.

That stress should produce an influence on magnetic quality is a probable result of the strain to which the stress gives rise. The effect of a simple longitudinal stress is, as we have seen, to make the metal, originally isotropic in its magnetic quality, become æolotropic, and it may be conjectured that this happens through differences becoming established in the pitch of the molecular magnets, in lines respectively along and across the direction of the stress, whereby old lines of molecules break up and new lines are formed. A uniform dilation or a uniform compression (with equal intensities of stress in all directions) might be expected to have a much less considerable influence on magnetic quality than a simple stress has. Experiments on the effects of such stresses are wanting; it may be anticipated that effects resembling those due to change of temperature would be observed. Thus we might expect to find a uniform pressure in all directions associated with a general reduction of magnetic susceptibility. The experiment would be an interesting one to carry out, especially in nickel, where (§ 122) the susceptibility is known to be greatly increased by a single stress of compression applied in the direction of magnetisation.

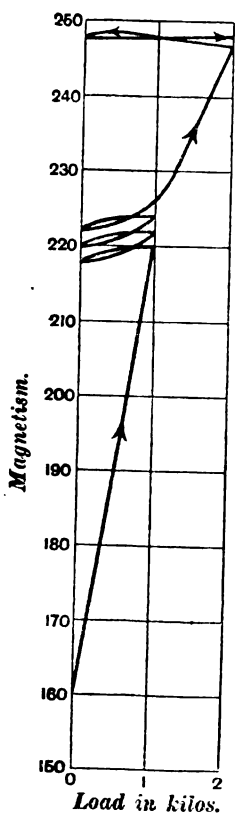

Fig. 157.—Effects of Loading a Soft Iron Wire in a Weak Magnetic Field.

A stress of simple pull will lengthen those rows of molecules which lie more or less along the axis of the stress, and will shorten those rows which lie more or less across the axis. This is enough of itself to develop differences of magnetic susceptibility in the longitudinal and transverse directions; and the difference is probably much enhanced by a re-arrangement of the molecular rows, the longitudinal rows being more or less broken up and transverse rows formed. The lengthening of the longitudinal rows will tend to increase the susceptibility; the shortening of the transverse rows, and still more the secondary consequence of stress, namely, the formation of new transverse rows, will tend to reduce it. It seems that in nickel the latter effect is the dominant one; in iron, on the other hand, we find a conflict of influences which makes pull favourable or otherwise according as the magnetisation is less or greater than a critical value.

The large magnetic changes due to torsion, which are seen in experiments in nickel, such as the reversal of magnetism which Nagaoka found when a loaded nickel wire is twisted to and fro to alternate sides (§ 142)—appear to be secondary effects, due to the reconstruction of molecular rows which become unstable when the molecular centres are displaced by the strain. It is the existing magnetism of the piece that is being affected, rather than its susceptibility to induction by the field.

An obvious conclusion from the molecular theory is that there should be, as we know there is, hysteresis in the changes of magnetic quality that are associated with changes of stress, and also that the condition arrived at by applying a load first and then magnetising should in general be different from the condition arrived at by first magnetising and then applying a load. (*See* §§ 120—131).

Another fact which the molecular theory serves to explain is the important difference which experiments reveal between the effect that is produced by the first application of a stress, and the effect that is produced when the same stress is applied after it has been previously applied and removed many times. After what has been said above in § 127, a brief reference to this matter will suffice. Provided the magnetising force is not very strong, the first application of load, when the piece hangs in a steady magnetic field, upsets molecules which were nearly upset before the load was applied. Removal of the load does not make these molecules recover the position from which the application of the load disturbed them. Thus successive loadings and unloadings, especially in a weak field, serve, as it were, to shake in the magnetism; and, if residual magnetism is dealt with, the field having been removed, successive loadings and unloadings serve to shake it out. Examples of this have already been given in Figs. 108 and 109, where the effects of a first loading and unloading are readily distinguishable from those that occur after a cyclic régime has become established by repetition of the cycle of loads. In strong fields, as the theory would lead us to expect, the cyclic régime is quickly attained; a second loading is enough to show that the initial disturbing influence of the stress is exhausted. In weak fields, the loading has to be repeated many times before that is the case, and the first disturbance is sometimes immensely greater than the alteration of magnetism that accompanies each application and removal of the load after a cyclic condition has been reached. Fig. 157 gives an example. The specimen dealt with there was a long wire of soft annealed iron, 0·76mm. in diameter, which hung in a weak field ($H = 0{\cdot}34$). A load of 1 kilogramme applied for the first time raised the magnetism from 159 to 220 (in arbitrary units). Removal of the load reduced it only to 218. Reapplication brought it up to 222; a second removal reduced it to 220¼. A third application made it 224, a third removal 222, and a fourth application 225½. Then the load was increased to 2 kilogrammes, and the magnetism went up at a bound to 247, when again successive unloadings and loadings produced but slight changes which tended gradually to assume a cyclic character when the operation was repeated many times.*

§ 188. **Hysteresis in Changes of Molecular Configuration, apart from the Existence of Magnetisation.**—In §§ 133-135 experiments have been referred to which show that when iron is subjected to cyclic variation of stress, its structure undergoes changes that involve hysteresis, even when no magnetic force acts upon it, and there is no magnetisation of the piece as a whole. The molecular theory makes the reason of this sufficiently apparent. Elastic strain brings about a rearrangement of the molecular grouping; old combinations break up and novel combinations are formed, although no magnetic forces are concerned other than the forces which the molecuiar magnets exert on one another. These changes of configuration involve unstable movements on the part of the molecules, and hysteresis consequently manifests itself, when the piece is carried through a cycle of strain. We find, for instance, that when an iron wire under tension is loaded and unloaded, by putting on and taking off weights, there is a distinct difference in the physical state of the metal, under one and the same intermediate amount of weight, during loading and during unloading. The difference shows itself in magnetic susceptibility, in thermo-electric quality,† and possibly in many other physical qualities of the material. It continues to be found when the cycle of loading is repeated, and its character is just such as the molecular theory would lead us to expect.

This hysteresis in molecular configuration, apart from all actual magnetisation, which exhibits itself when the piece is carried through a cycle of elastic strain, has one important consequence. It implies that the elasticity of the substance is not perfect. The unstable movements of the molecules, to

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* For details of this and other experiments illustrating the point now referred to, see *Phil. Trans.*, 1885, p. 594, *et seq.*

† See *Phil. Trans.*, 1886, p. 361.

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which it is to be ascribed, result in a dissipation of energy. More work has, therefore, to be spent in stretching the piece, while loads are being put on, than is recovered when the loads are taken off—in other words, the stress that corresponds to any given intermediate value of the strain must be greater during the application of the load than during its removal. There must be hysteresis in the relation of strain to stress; and, as we have seen already (§ 135), this conclusion is borne out by experiment.

§ 189. **Experimental Study of Molecular Groups by means of Models.**—It is extremely helpful, in considering the constraint which the molecular magnets suffer in consequence of their polar forces, to experiment with a model consisting of a

Fig. 158.

number of short steel magnets, pivoted like compass needles on fixed centres, and placed near enough to one another to allow the mutual control to be felt.* Such a model is readily made out of pieces of stout magnetised steel wire, bent, as in Fig. 158, to bring the centre of gravity below the pivot point. A recess for the pivot is stamped by a centre punch in the hollow of the bend, and the pivot itself is a needle stuck, with the point

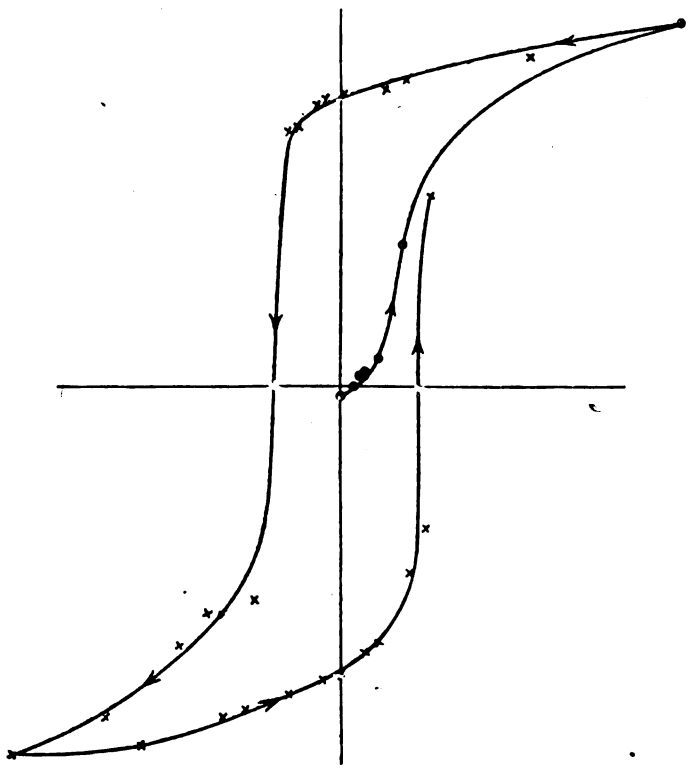

Fig. 159.—Cyclic Process applied to a Group of Twenty-four Pivotted Magnets.

upwards, in a small block of lead or of wood. Instead of a wire, a piece of steel plate may be used for the magnet, and this may have any form given to its polar extremities, from sharp points to semicircles. The magnets being of hard steel, strongly magnetised, are practically unaffected (as to the intensity of their magnetism) by the comparatively weak external magnetic forces which one applies to turn them into line. The external force may be applied by a coil wound in an open manner over a light framework, within which the group of magnets is placed, the open winding allowing the behaviour of the magnets within to be observed. Or a larger coil placed entirely underneath the group may be used; or, better still, a pair of closely-wound short coils placed one on either side of the group. This last form is especially convenient when the behaviour of the group is to be exhibited by projecting them on a lantern screen. For that purpose short magnets are necessary, and the magnets used for small pocket compasses will be found very suitable; the pivots themselves may also be cut out of such compasses and cemented, at proper distances, on a glass plate. To exhibit the effects of strain, the pivots may be arranged on a framework of jointed wooden rods, forming two crossed sets of parallel lines; by placing the pivots at the joints, or midway between the joints, some of the effects of simple shear or simple pull and push may be studied.

A model of this kind allows the three stages of the magnetising process to be readily distinguished. The phenomena attending reversal of magnetism, the dissipation of energy in hysteresis, the conditions that promote residual magnetism, the comparative effects of slow and sudden changes in magnetic force, the primitive and final effects of strain, the influence of vibration, the existence of time-lag, are all matters of which the model gives effective illustration.

The manner in which the resultant polarity of the group of pivoted magnets changes when the field is applied, reversed, or varied in any way, is sufficiently evident on mere inspection of the group. It may, however, be determined quantitatively by using a magnetometer in the ordinary way, taking care to compensate for the action of the coil which supplies the magnetic field by placing in series with it a second coil, the position of which is adjusted to annul the deflection which the first coil by itself would produce. A group of magnets examined in this way, when carried through a cycle of configuration by applying and reversing the directive force of the coil, gives what we may call curves of magnetisation, in which all the main characteristics of the ordinary curves for iron appear, though, of course, the limited number of magnets which it is practicable to use in such an experiment makes the steps of the process more jerky than they are when we have to deal with the multitudes of molecules in a piece of solid metal. Curves obtained by this means, showing the reversal of a group of twenty-four little magnets (like Fig. 158) under reversal of the directing field, are given in Fig. 159.*

§ 190. **Ampère's Hypothesis as to the Nature of the Magnetic Molecules.**—Granting, as we very well may (in view of the considerations summarised in this chapter), that the process of magnetising consists in turning round molecules that are already magnetic, so that their axes tend, under the directing force of the applied field, to approach a particular direction, the question still remains, to what is the primitive magnetism of the molecules due? Weber's theory does not help us to an explanation of the fact, which it postulates, that each molecule is a permanent magnet.

According to the hypothesis of Ampère the magnetism of the molecule is due to an electric current continually circulating within it—in other words, the molecule is a conducting circuit in which a current flows, and when a directing field acts, the channel in which this current flows tends to set itself at right angles to the direction of the field, just as does the coil of an electro-dynamometer. Ampère's theory, therefore, explains all the phenomena of magnetisation as consequences of the mutual action of electric currents. According to it, in magnetising a piece of iron we are dealing with the forces which exist between the current in an external conductor and the currents in molecular circuits within the metal, which are prevented from immediately putting themselves into perfect parallelism with the external circuit only because of the forces which the currents in the molecules exert on one another. In this view the model of a magnetic metal should be constructed, by using not pieces of permanently magnetised steel to represent the molecules, but little coils, free to turn, in each of which an electric current flows continually.

*Proc. Roy. Soc., 1890, Vol. XLVIII., p. 342; *Phil. Mag.*, September, 1890

* Fig. 159, for which the author is indebted to Mr. Glazebrook, represents the results of an experiment by Mr. J. W. Capstick, made in answer to a question set in the practical examination of the Cambridge Natural Science Tripos, 1891. Curves of this kind were first published by Mr. Arthur Hoopes in the *Electrical World* (New York), May, 1891. See *The Electrician*, May 29, 1891.

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The molecular channels must be supposed to offer no resistance as conductors, otherwise the primitive currents would require energy to be expended in maintaining them.

When a field is applied it tends to turn the molecular circuits, and it also induces supplementary currents in them. These induced currents are superposed on the primitive currents; their strength depends on the inclination of the circuit to the field; and their general effect is to reduce the primitive currents. Whether they will do so to any great extent depends on the area and the self-induction of the molecular circuits, and on the primitive strength of the currents in them.* Thus if the primitive currents are strong and the other conditions favourable, very little reduction of the primitive strength takes place through this induction of current by the applied field. In that case the molecular circuits are nearly equivalent to strictly permanent magnets, and merely turn in response to the field, without suffering any material loss of intensity. Probably this represents what occurs when iron or any of the other strongly magnetic metals is magnetised.

When the primitive molecular currents are weak the induction of opposing currents by the application of a magnetic field may modify the resultant strength very greatly; and in particular, when there are no primitive currents at all, but only conducting molecules ready to have currents induced in them, the application of the field will induce currents which give to the piece a polarity of the kind opposite to that which it acquires in ordinary magnetisation. By recognising the existence of these induced currents Weber thus extended Ampère's theory of molecular conducting circuits to account for *diamagnetism*.

But even when there are strong primitive currents, as we must suppose there are in the molecules of iron, the induction of opposing currents, in consequence of applying a magnetic field, will go on to some extent, and there is a stage at which its influence may be appreciable. This is when the piece is saturated—when all the molecular circuits are turned into planes perpendicular to the direction of the field. In that position they are as favourably placed as possible for the induction in them of currents opposed to the primitive currents. When the field is further strengthened, the resultant current in each molecular channel is reduced, and as the channels are already all perpendicular to the field, the only effect of increasing the field is to reduce the magnetisation by reducing the strength of each molecule. The Ampère-Weber theory, therefore, leads us to conceive of the magnetism of iron as tending to pass a limiting value when saturation is reached, after which a stronger magnetising force should actually weaken the magnetism. The results of experiments with very strong fields neither confirm this nor contradict it. They show that when the condition of saturation has been approached the field may be strengthened ten-fold or more without any material change in the magnetisation, either in the way of addition or loss. But the conditions under which those experiments are carried out make very accurate measurement impracticable, and a small reduction of the magnetism might pass undetected. It is probable enough that stronger fields still must be used to discover it, for the reduction to be expected as a consequence of induced currents in the molecular channels is slight at the most, and in the approach to saturation which is long drawn out, the continued deflection of the molecules tends to counterbalance any effect that may be produced by a small loss of moment on the part of each.

GERMAN GAS AND ELECTRIC LIGHT STATISTICS.

BY CLARENCE FELDMANN.

Under the title of "How shall we build our central stations?" Herr Friedrich Ross, Director of the Helios Company of Ehrenfeld, has published a pamphlet written especially for municipal authorities. The author states in the preface that he is a partisan of the alternate-current transformer system, and then gives some details of a few German central stations working with accumulators, from which I extract the following:—The central station of Barmen delivered to the mains from the 1st of May, 1890, till the 10th of the same month 1,771,653 watt-hours, the total output of the dynamos being 2,681,970 watt-hours. The charge of the accumulators was 1,759,731 watt-hours, and their discharge 547,356, giving a mean efficiency of 37 per cent. Shortly afterwards the battery had to be reconstructed on account of buckling of the plates. From the 20th to the 28th of September, 1890, the efficiency amounted to 55·8 per cent., the total output of the dynamos being 3,769 kilowatt-hours, and the consumption in the network 2,985 kilowatt-hours, the accumulator charge 1,784 kilowatt-hours, and the discharge 996·5 kilowatt-hours. Similarly the mean efficiency of the central station of Darmstadt was 38·6 per cent. in 1889 and 55·9 per cent. in 1890, after the accumulators had been reconstructed towards the end of August, 1889.

All central stations working with accumulators have been planned on the assumption of a rather low number of hours of daily maximum consumption; and the author asserts that such statements are erroneous, or are so in most cases. He shows from the gaswork statistics of 24 of the largest German gasworks that the gas supply for heating and power purposes amounts to only 6½ per cent. of the total output, and that for 16 other gasworks the hours of heavy consumption were, on an average, 8·7. Another table contains the maximum consumption in one day, and in one hour of this day, for several electric stations, and shows the quotient of these two quantities, which gives the hours of maximum load: Berlin, 8·8; Barmen, 6·9; Elberfeld, 5·6; Hamburg, 8·2.

Some interesting details of the Düsseldorf central station are then given. It is stated, among other things, that in Darmstadt the total length of gas main is about 116 kilometres for, approximately, 35,000 gas lights, or 3·3 metres of main per gas burner, corresponding to one 16 candle-power lamp. The electric network is planned with about 32 kilometres of mains for about 20,000 16 candle-power lamps, or with 1·6 metres of mains per lamp. For the central stations of Darmstadt and Elberfeld Herr Ross gives the cost of current production per 16 candle-power lamp-hour as 2·45 and 1·33 pfennigs (one pfennig = ·12d.) respectively, the annual cost per lamp being 3·55 marks in Darmstadt and 4·8 marks in Elberfeld. For these two stations the maximum consumption is nearly equal, but the average annual number of lamp-hours is 289 in Darmstadt and 730 in Elberfeld.

In the last table are given some average values for the annual lamp-hours, the length of main per light, and the ratio of daily maxima to total lamps installed, all calculated from the statistics of 35 gasworks of various sizes; these three numbers varying from 1,610 to 1,270 hours; 2·49 to 4·4 metres, and 50 to 57 per cent.

* *See* Maxwell's "Electricity and Magnetism," Vol. II., chap. XXII.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, November 6th. (To-night.)

PHYSICAL SOCIETY.

5 p.m. Paper to be read on "Corresponding Temperatures, Pressures, and Volumes." By Prof. Sydney Young.

TUESDAY, November 10th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meetings. Address by the President, and Presentation of Medals, Premiums, and Prizes awarded during last Session.

THURSDAY, November 12th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Paper to be read, "Description of the Standard Volt and Ampere Meter used at the Ferry Works, Thames Ditton." By Capt. H. R. Sankey and F. V. Andersen.

FRIDAY, November 13th.

INSTITUTION OF ELECTRICAL ENGINEERS.

7 p.m. Annual Dinner at the Criterion Restaurant, Piccadilly.

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SPECIAL NOTICE.—IN ACTIVE PREPARATION.

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MODERN MAGNETIC SCIENCE.

If it were desired to illustrate the truly radical changes which have swept over experimental science during the past twenty years it would be scarcely possible to select a more striking example than that afforded by the science of magnetism. Only ten years ago the old terms derived from the ancient action-at-a-distance ideas were in vogue, and magnetic poles with their supposed surface-distribution of the imaginary magnetic fluid or fluids were the all-in-all of this branch of science. This was quite sufficient for the requirements of the ordinary examiner of the University; it was susceptible of being decked out with an endless array of mathematical symbols. The differential equations for the forces between two poles at a distance being once established, it was a fine exercise for the expert mathematician to evolve from his imagination some supposed law of surface distribution, and then duly to work out the integration of his symbols to find the

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resulting force. But this was all so much elegant beating of the air. His array of symbols corresponded to nothing real either in the heavens above or in the earth beneath. The species of magnetism thus mathematically evolved differed widely from the actual magnetism which the practical man had to deal with in the industries, whether for telegraphic relays or for dynamo-machines. The real magnetism obstinately refused to distribute itself in accordance with the sextuple integrals of the mathematician, or to walk along the exquisite scaffolding of the three rectangular co-ordinates which he had painfully erected. One thing had unfortunately been left out of sight by the abstract mathematicians in their treatment of magnetism; but that one thing was precisely the most important fact of all. They had quite lost sight of the magnetic properties of the materials. They were looking at the magnet from the outside only, instead of considering the internal conditions, of which the so-called poles are only the external, and, as it were, the accidental manifestations. True they used, in a vague way, the term "coercive force," to express some sort of a property of the material, by virtue of which it kept the two supposed magnetic fluids from following their own natural tendency to run together and neutralise one another. But what the coercive force was they could not tell us, nor how much it was; nor could they give any rational account of the alleged fluids.

All this old and semi-metaphysical stuff has gone for ever. The modern science of magnetism begins where the older science left off—with the properties of the materials. It is with the properties of the materials, their permeability, their retentivity, and their hysteresis, and the variations of these properties under varied physical conditions, such as temperature and stress, that modern magnetic science deals. Hundreds of different brands of iron and steel have been now examined to ascertain their magnetic properties under all possible conditions. They have been subjected to all possible degrees of magnetising force from the strongest to the weakest; sometimes slowly, sometimes in rapidly recurring cycles. They have been heated and cooled, compressed and elongated, twisted, vibrated, and laminated; with the result that our present knowledge of the facts of internal magnetism is marvellously complete. We have learned, in fact, to look at a magnet from the inside instead of the outside, and know what the inside facts are.

In this great advance many workers have contributed to the accumulating stock of knowledge. But amongst them there is one whose ten years of self-imposed labour will never be forgotten, namely Prof. Ewing, from whose pen a series of articles on magnetism have been flowing in the columns of this journal throughout the past twenty months. We take the occasion of the publication to-day of the concluding article of his series to point out the invaluable services which Prof. Ewing has rendered to the electrical world by his work in a field which he has made so peculiarly his own. Had he performed no other service than to examine the phenomena of hysteresis, and to coin for us that most useful name to denote the group of facts for which a name was so long wanted, he would have earned the gratitude of every worker in magnetism. Had he done nothing more than investigate the effects on magnetism of compression, tension, and torsion, he would have assuredly gone down to scientific posterity for his careful and intelligent unravelling of the complex phenomena exhibited by magnetic substances in these relations. Had he never done anything else than produce that brilliant bit of speculation, the molecular theory of magnetism, by the aid of which he is able to explain so many of the more obscure facts without calling in the aid of adventitious internal frictional forces, he would have justly earned a scientific renown. But even so, he would have only been, so to speak, the equal of the Hopkinsons, the Warburgs, the Rowlands, the Bosanquets, the Bidwells, and the Tomlinsons who also have made valuable scientific investigations in kindred matters. But Prof. Ewing had done one thing more which none of these other investigators have done; he has given to the wider world of workers the opportunity of learning for themselves what these various researches are, and to what they lead. Other investigators have been content to consign their results to the sacred custody of the *Transactions* or *Proceedings* of the Royal Society or other learned body, where they remain practically buried for the vast majority of electrical engineers. How many of our readers have ever seen the original memoirs of Mr. Bidwell we do not know. How many of them ever heard of the hundred and seventy-page quarto of Mr. Tomlinson's work we scarcely dare to inquire. And how many of them would know of Prof. Hopkinson's work, if it had not been published elsewhere than in the *Philosophical Transactions*, we need not ask.

It seems to us, indeed, that the Royal Society itself is not free from blame in the extreme inaccessibility which it throws around its most important publications. Why it should charge such absurdly high prices for the memoirs it prints is a conundrum only to be answered by asking another: Why it prints so few copies that the price must necessarily be high? Surely a body so highly endowed cannot wish to make trading profits on its publications. The memoirs of Ewing alone, as published by the Royal Society, cost 16s., whilst a single one of Hopkinson's is charged 7s. In the face of such prices one might almost suppose that the Royal Society was anxious that the memoirs it publishes should not be read by any outsiders.

Professor Ewing has, however, come to the rescue. In the articles which we have had the honour of publishing, he has set forth, in simple, straightforward language, the work which he and other investigators have done to enrich magnetic science. And, in thus placing the rich stores of his information at the disposal of a wide circle outside the narrow limits of the scientific societies, he has conferred a real and lasting boon upon the electrical fraternity throughout the world.

THE FRANKFORT EXHIBITION.—XVI.

(FROM OUR SPECIAL CORRESPONDENT.)

The Thomson-Houston exhibit attracted particular attention. A single cylinder 100 H.P. engine, by McIntosh and Seymour, drove a 40-kilowatt, 220-volt compound machine. In addition to this dynamo there was an ordinary Thomson-Houston arc lighter. From the compound machine wires were run to the Thomson-Houston pavilion, where the current drove a dynamo-motor. In addition to the fixed brushes there was a second rotating pair of brushes. This pair revolved at a speed of 325, the armature running at 1,600 revolutions. By means of this strange device one and the same machine can be made to give a continuous current, an alternating current of 325 ∿ per minute, and a pulsating current. The continuous current is taken off the fixed brushes, the alternating off the rotating brushes, and the pulsating current is obtained by using one or other of the two fixed brushes and one of the rotating brushes.

In Dr. Otten's recent Paper on "The Application of Electricity to Mining," † a number of applications to which these currents, continuous, alternating, and pulsating, may be put are considered in some detail; and it may be worth while to draw attention to the way in which the alternating and pulsating currents are employed in connection with the much-illustrated but little known Van Depoele reciprocating drill, which is exploited by the Thomson-Houston Company.

† Elek. Zeit. 12: 634 Nov 20, 1891

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Three coils, 1, 2, 3 (*see* diagrammatic sketch, Fig. 1), are wound side by side and fixed firmly in an iron casing, an iron core, to one end of which the drill is fixed, being introduced into the coils. The two outer coils, 1 and 3, are in series, but oppositely wound so that the current passing through them produces an equal and opposite magnetising effect. The two outer coils are com-

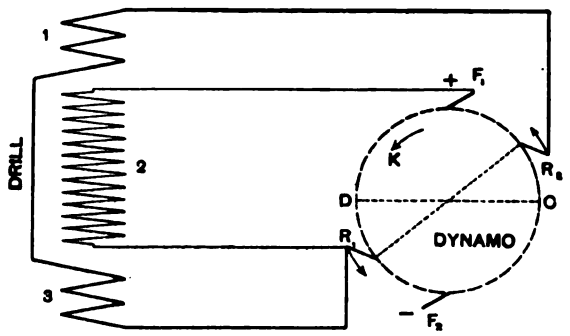

FIG. 1.—Van Depoele Reciprocating Electric Mining Drill. Connection of coils with source of power.

posed of a few turns of thick wire, while the middle coil, 2, consists of a large number of turns of fine wire; and it is this coil which has the chief magnetising effect. The method of circuiting the coils is shown in the figure, where F_1, F_2 are the fixed brushes and R_1, R_2 the rotating brushes. From this diagram it will be seen that the outer coils are connected in series with the rotating brushes $R_1 R_2$, and traversed therefore by an alternating current, the phases of which, neglecting for simplicity's sake the consideration of self and mutual induction, are substantially as shown by the thin curve (Fig. 2), while the inner coil is traversed by a pulsating current, the poles being the positive brush F_1 and the rotating brush R_1, the pulsations of the current being represented by the thick line in Fig. 2.

In the same diagram (Fig. 2), vertically under each of the points F_2, C, F_1, D, F_2, are sketched the corresponding polarities assumed by the two coils 1 and 3, and at the sides are also sketched the corresponding positions and polarities of the iron core I, the direction in which it is moving or tending to move being shown by the arrow heads. Starting at C, we have the outer coils 1 and 3 unexcited, and the iron core lies symmetrically with respect to them. Immediately after point C polarities are induced, as shown in the diagram, and are clearly such that coil 1 repels and coil 3 attracts I. As we move from C to F_1 the magnetism induced by the pulsating current round the core and iron casing dies away, so that the South pole of I, which is sucked down into coil 3, dies out, thus preventing the repulsive effect of the S pole of coil 3 then reaching its maximum. In this way I is pulled down with considerable force to the outer end of coil 3, the momentum of the core being destroyed by the drill striking the material worked upon. After

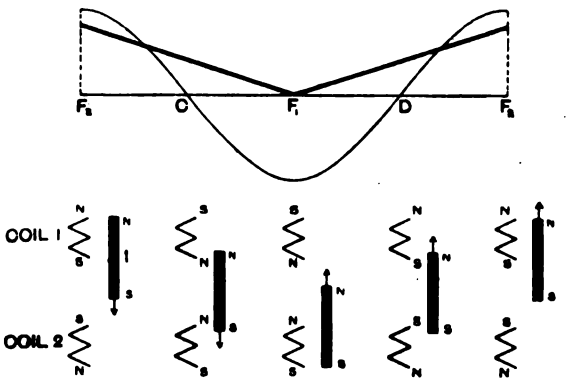

FIG. 2.—Van Depoele Reciprocating Electric Mining Drill. Phases of the pulsating and alternating currents supplied, and corresponding positions of the reciprocating iron core.

the point F_1 the magnetism of the core and of the casing (both unreversed) again grows. The three like (South) poles repel each other, and the core I is driven out of coil 3. After point D, it will be seen that the polarities of the coils 1 and 3 are reversed, so that I is drawn into coil 1. The magnetism of the core is, however, increasing, and reaches its maximum at the same time as that of coils, and three similar (North) poles approaching each other as the coil nears the outer end of coil 1, namely, those of the iron casing, of the core and of the coil; the core is brought to a stand without striking the end of the iron casing. The core I is then pushed out of coil 1 again, and the cycle repeated.

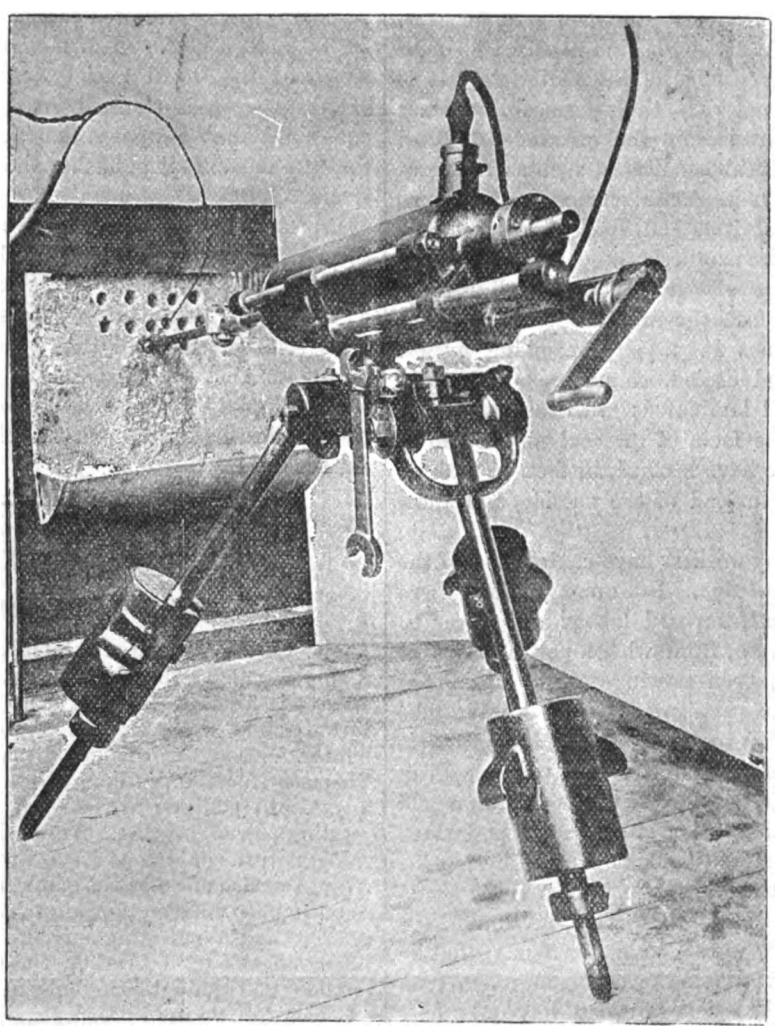

FIG. 3.—Van Depoele Reciprocating Electric Mining Drill. General view.

The number of strokes per minute is about 325. The length of the stroke is nearly 5½in., and at every stroke the drill turns automatically the eighth part of a revolution round its axis, so that the hole made is bored evenly out into a cylindrical form. The whole apparatus, which is shown in Fig. 3, stands on a tripod with weighted legs, easily set up, and all the man in charge has to do while drilling a hole is to keep slowly turning the lever handle shown in the illustration, in order to advance the instrument forward at the same rate as the hole is being bored, and to see that the material worked upon is supplied with water at the part operated on. The drill is of very solid and simple construction, and apparently not likely to get out of order or suffer much from rough treatment. The weight of the instrument, exclusive of the stand, is just over 4cwt., the stand, with the movable weights fastened on the legs, weighing

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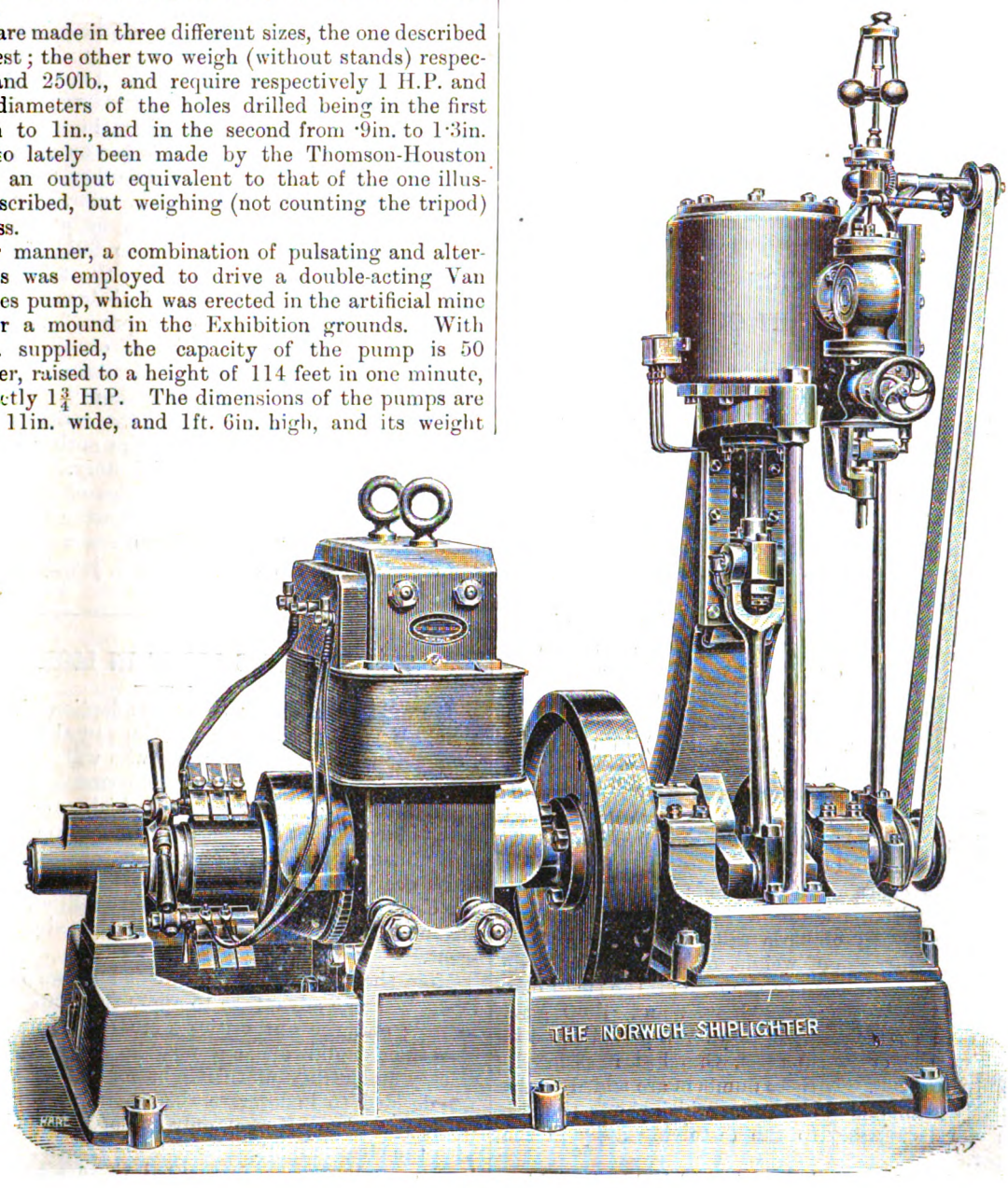
about the same. The power absorbed amounts to about 2 H.P. in drilling holes of from 1½in. to 2in. In hard granite the drill is said to be able to bore a hole 1·7in. diameter and 15¾in. deep in a space of ten minutes. In the experiments at Frankfort on Odenwald granite and gypsum the figure in the case of granite exceeded the above, and in the gypsum blocks holes of diameter 1·4in. and depths of 7·9in. were made in a minute when water was used, the depth, however, without water reaching only 4·7in.

These drills are made in three different sizes, the one described being the largest; the other two weigh (without stands) respectively 134lb. and 250lb., and require respectively 1 H.P. and 1¼ H.P., the diameters of the holes drilled being in the first case from ·4in to 1in., and in the second from ·9in. to 1·3in. A drill has also lately been made by the Thomson-Houston Company with an output equivalent to that of the one illustrated and described, but weighing (not counting the tripod) 28 per cent. less.

In a similar manner, a combination of pulsating and alternating currents was employed to drive a double-acting Van Depoele-Knowles pump, which was erected in the artificial mine arranged under a mound in the Exhibition grounds. With 2½ to 3 H.P. supplied, the capacity of the pump is 50 gallons of water, raised to a height of 114 feet in one minute, *i.e.*, almost exactly 1¾ H.P. The dimensions of the pumps are 3ft. 5in. long, 11in. wide, and 1ft. 6in. high, and its weight is about 7cwt., figures which speak well for its employment wherever space is an object.



Laurence and Scott's Shiplighting Set.

LAURENCE AND SCOTT'S SHIPLIGHTING SET.

The accompanying illustration represents one of Messrs. Laurence, Scott and Co.'s shiplighting sets, S.L. 5 type. The output of the one illustrated is 65 volts, 140 amperes, at 260 revolutions per minute. The engine is provided with very large bearing surfaces and ample lubricating arrangements, but otherwise calls for no special mention. The weight of the dynamo field-magnets is taken through brass packing pieces on two strong ribs that run across from one side to the other of the bedplate, whilst they are held in position by means of the Muntz metal studs coming through the strong brackets on the side of the bedplate, circular brass distance pieces being arranged between these brackets and the magnet poles. The armature of the dynamo is of Laurence, Scott and Co.'s usual type, the conductor being wound in slots milled into the plates which form the armature core. These plates have hexagon holes, into which the hexagon steel shaft is driven, with insulating pieces.

It is necessary that the width of the slots should not exceed a certain amount. In practice these makers find it should not be more than twice the clearance between the armature and the pole pieces. In the commutator of the above machine there are 110 sections, one turn of conductor to each section; but there are only 55 slots cut in the armature, each ·355in. wide. This would be an excessive width, but in winding each slot is made into two by means of three longitudinal strips of charcoal iron, running the whole depth and length of the slot, but insulated from both the conductor and the armature core. These strips reduce the width of each slot to ·14in., and thus make the outside surface of the armature sufficiently even magnetically to entirely do away with the heating of the pole pieces and the noise that would have been caused by the wider slots. The armature of the machine is 13⅛in. diameter outside, 11⅛in. at the bottom of the slot, and 9in. long. It is

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wound with four parallels of No. 13 wire braided. The magnets call for no special mention. They are of Lowmoor iron, and have a sectional area of 85 square inches. The ampere turns in the shunt are 9,370, and in the series 7,840.

The set illustrated was worked up to 200 amperes for six hours before leaving the makers' works. Even with this very excessive load there was no sparking, and the rise of temperature in the armature at the end of the test was only 80°F. The makers have recently obtained a licence from Mr. Gisbert Kapp to use his patent end connections for bar armatures, and these will be used in the large machines. They have been making a large number of shiplighters for Scotland and the North of England during the last eighteen months. They have had an absolutely clean record with them, not a single breakdown having occurred up to date.

ON THE APPARENT VARIATION OF THE ELECTRO-CHEMICAL EQUIVALENT OF COPPER.*

BY M. VANNI.

Many investigators have called attention to, and Mr. Thomas Gray† has made a special study of, the influence which the current density at the cathode of a copper voltameter appears to exert on the electro-chemical equivalent of that metal as deduced from the increase of the weight of the negative electrode. The author proposed to himself to verify the hypothesis which attributes the observed variation to the dissolving action of the sulphate of copper solution on the copper.

In the experiments two voltameters in series were always employed. The negative electrodes consisted of sheets of copper of good commercial quality, covered with a layer of electrolytically deposited copper. The portion of the electrode in contact with the liquid had a surface of 58 sq. cms. (9 sq. in.) in one, and of 14·5 sq. cms. (2·25 sq. in.) in the other voltameter. The anodes were also sheets of copper, covered with a deposit. The weighings were carried to the half milligramme (·0075 grain). The sulphate of copper solutions had a density of 1·12; they did not contain any free sulphuric acid revealed by using methyl orange.

The first series of experiments was made by adding 10 per cent. of sulphuric acid, this addition having for object the prevention of the formation of basic salts. Under these conditions the observed increase of weight of the large cathode was always considerably less than in the case of the small one. The following are the figures:—·1903 grm. and ·1960 grm. If the cathodes were left in the solution for a period equal to that during which the current passed, they lost respectively 9·2 and 3·2 milligrammes. If these numbers are added to the first we get ·1995 grm. and ·1992 grm., which shows that we may attribute the discrepancy to the dissolving away of the deposited copper.

It only remained to discover the way in which this disturbing action could be suppressed. This object was not attained either by leaving copper turnings for a long time in the solutions, or by trying to neutralise the acid by means of copper hydride carefully washed and dried. Finally, it was observed that by dissolving pure sulphate of copper, twice crystallised, a liquor was obtained in which a sheet of copper increased in weight (the increase was probably due to the brown layer which formed on the plate). It was then only necessary to mix this solution with another containing 1 per cent. of sulphuric acid, in the proportion of 1 litre of the first to ·59 of the second, to obtain a liquid which had no dissolving action on copper; this liquid also was neutral. The experiment of placing the sulphate of copper voltameters in series with one containing nitrate of silver was then carried out in order to determine the ratio of the electro-chemical equivalents of the two metals.

* *Wied. Ann.* Translated from *La Lumière Électrique.*
† *Phil. Mag.*, Vol. XXII., p. 389, Vol. XXV., p. 179.

The following table gives the results of six experiments:—

	Duration of experiment in hours.	Average current amperes.	Weight of copper deposited. Large plate.	Small plate.	Mean.	Weight of silver deposited.	Ratio.	Electro-chemical equivalent of copper.
1	1	·292	·3447	·3449	·3448	1·1740	·2937	3.284×10^{-7}
2	2	·228	·5396	·5397	·5397	1·8360	·2936	3.283
3	2	·221	·5228	·5232	·5230	1·7802	·2938	3.285
4	2	·150	·3535	·3531	·3533	1·2021	·2939	3.286
5	1	·230	·2717	·2714	·2716	·9251	·2936	3.282
6	1	·245	·2904	·2900	·2902	·9870	·2940	3.287
							·2938	3.284×10^{-7}

It will be seen that the numbers in the third and fourth columns never differ from each other by as much as five units in the fourth place of decimals, in other words they are equal within the limits of experimental error. The figures in the last column have been calculated by assuming the electro-chemical equivalent of silver to be ·001118. If we take the values of the equivalents given in the tables of Landolt and Boernstein, *i.e.* 31·59 and 117·66, their ratio is ·2934, and the electro-chemical equivalent of copper is $3{,}281 \times 10^{-7}$. It is to be observed that the equivalent of copper is known to within ·25 per cent., and that of silver to within ·05 per cent., so that their ratio is only known to within ·8 per cent. The discrepancy between the value of the ratio as given by these tables and that determined by the author is less than this. The agreement is, therefore, satisfactory.

It was assumed in the first series of experiments that the dissolving action of the solution remained the same when no current was passing. The results of the second series, in which the dissolving action was suppressed, justify this supposition.

THE ELECTRIC LIGHT IN LIGHTHOUSES.*

It would seem proper that the adoption of an improvement should be influenced above all things by the degree of appreciation of it which is felt by those who will be called on to make use of it; since, whether an improvement is really such often depends upon circumstances of which practical men are the best judges. This is indeed only common sense, but it is not governmental. What *is* governmental is to adopt an improvement everywhere simply because it is one somewhere. Thus the electric light possesses valuable qualities, and its numerous advantages will increase as it is perfected; it is an improvement.

Now, the Government, persuaded by an inventor, thought it would be an advantage to apply this improvement to lighthouses; and the authorities were not mistaken. What the Government did make a mistake about was the degree of efficacy and utility of this light for this special purpose. It was decided to inaugurate this reform at the two lighthouses of La Hêve (near Havre), only one of them being at first fitted with the electric light.

The mariners who frequented these parts soon discovered that if the electric light was superior to the oil light in clear weather, it was less and less penetrating and even became invisible in foggy weather; while the latter, losing considerably less, remained visible much longer. This was an experimental proof that the fog-penetrating power of the electric light was notably less than that of an oil light. The reason for this was given, if we remember rightly, some ten years ago by a clever engineer in the lighthouse service, M. Lucas, and we mentioned the matter at the time. We regret to say that we have mislaid M. Lucas's paper.

In a private concern, such a statement duly verified would condemn a system, since granting the ingenuity of a system its efficacy would have to be superior to that of a commonplace method. But the utility of lighthouses increasing with the density of a fog, it is doubly absurd to retain a method of lighting the efficacy of which increases with the clearness of the atmosphere, but diminishes and becomes zero much more

* From the *Moniteur Industriel.*

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rapidly than that of the older system at the very moment when the light is most wanted. But Government, once set in motion, does not stop for such a trifle. The electric light already installed in the chief lighthouses will soon be found in all. Let the sailors get out of the difficulty as best they can! and are they not satisfied at being in the right when science is in the wrong? There being moreover a spirit of emulation between country and country, and Governments being much the same everywhere, electricity has taken or is about to take the place of oil on most coasts. England, whose *amour-propre* often obscures its practical way of looking at things, has made the same mistake.

According, however, to a contemporary the English Association of Master Mariners has lodged complaints at Trinity House with regard to the insufficiency of the electric light in lighthouses, and the various inconveniences which it presents to navigators. They allege that they have often had occasion to observe at the mouth of the Thames the inefficacy and low power of the electric lights, which are often invisible under certain atmospheric conditions, whilst the oil lights of the lightships or the gas lamps of the seaside towns are perfectly visible. Moreover, the glare of a powerful light, such as the one at South Foreland, inconveniences ships in its vicinity in another way: it dazzles the navigators, who are, therefore, unable to keep a proper look out, and the intensity of the rays projects the shadows of hulls and rigging to a great distance, forming regular phantom ships and rendering it difficult to judge distances on a dark night.

We may be sure that the voice of the English mariners will be heard and taken notice of. England will not be deterred by the question of expense from giving satisfaction to the shipping interest, and adding to the security of her coasts; and if it is found necessary to increase the intensity of the lights in order to augment their range in bad weather, this difficulty will not cause her to draw back.

It would be a good thing if the same course were taken on all foggy coasts, and if the electric light were reserved only for those coasts where fogs are the exception. But we must not expect it, the Government must not stultify itself.

Let us take this opportunity of correcting an error into which people too often fall. What is wanted of a lighthouse is not that it shall *illuminate* the path of a ship, but that it shall furnish a luminous point; not that it shall show one where one is going to, but indicate to the mariner where he is and whither he should go. Lights are recognised by their colours, fixity, alternations of colours, durations of flashes. By these means a sailor discovers his whereabouts, and he is hampered rather than aided by a flood of light. It is, therefore, a mistake to choose the electric light for lighthouses because it affords the most powerful illumination. This, also, mariners would have told the Government if it had deigned to consult them.

ON THE DISCHARGE OF ELECTRICITY THROUGH EXHAUSTED TUBES WITHOUT ELECTRODES.*

BY J. J. THOMSON, M.A., F.R.S.

The following experiments, of which a short account was read before the Cambridge Philosophical Society last February, were originally undertaken to investigate the phenomena attending the discharge of electricity through gases when the conditions are simplified by confining the discharge throughout the whole of its course to the gas, instead of, as in ordinary discharge tubes, making it pass from metallic or glass electrodes into the gas, and then out again from the gas into the electrodes.

In order to get a closed discharge of this kind we must produce a finite electromotive force round a closed circuit, and since we cannot do this by the forces arising from a distribution of electricity at rest, we must make use of the electromotive forces produced by induction. To break down the electric strength of the gas such forces must be very intense while they last, though they need not last for more than a short time. Forces satisfying these conditions occur in the neighbourhood of a wire through which a Leyden jar is discharged. During the short time during which the oscillations of the jar are maintained enormous currents pass through the wire, and as with a moderate sized jar these currents change their direction millions of times in a second, the electromotive force in the neighbourhood of the wire is exceedingly large. To make these forces available for producing an electrodeless discharge, all we have to do is to make the wire connecting the coatings of the jar the primary of an induction coil of which the discharge tube itself forms the secondary. The arrangements which I have employed for this purpose are represented in the accompanying diagram.

In (α) A is the inside coating of a Leyden jar; this is connected to E, one of the poles of a Wimshurst electrical machine, or an induction coil, the other pole F of the machine being connected to B the outer coating, of the jar. A C D is a wire connected to the inner coating of the jar, a few turns C (which we shall call the primary coil) are made in this wire; these turns are square if the discharge tube is square, circular if the discharge tube is a spherical bulb. The wire at D is attached to an air break, the other side of which is connected with the outer coating of the Leyden jar. The knobs of this air break ought to be kept brightly polished. The loop C is connected to earth. The discharge tubes, which were in general either rectangular tubes or spherical bulbs, were placed close to the turns of C. When the difference of potential between A and B is sufficiently large, a spark passes across the air break, and the electrical oscillations set up produce a large electromotive force in the neighbourhood of the coil, sufficient under favourable circumstances to cause a bright discharge to pass through the vacuum tubes. In some experiments the jars, at the suggestion of Professor Oliver Lodge, were connected up differently, and are represented by (β) in Fig. 1. Two jars were used, the outside coatings of which, A and B, were connected by the wire containing the primary coil C, the inside coating of the first jar was connected to one pole of the Wimshurst, that of the second to the other. With this method of arranging the jars no air space is required, as the sparks pass between the terminals of the machine, and the polishing of these terminals is not nearly so important as that of the knobs of the air break in the arrangement (α).

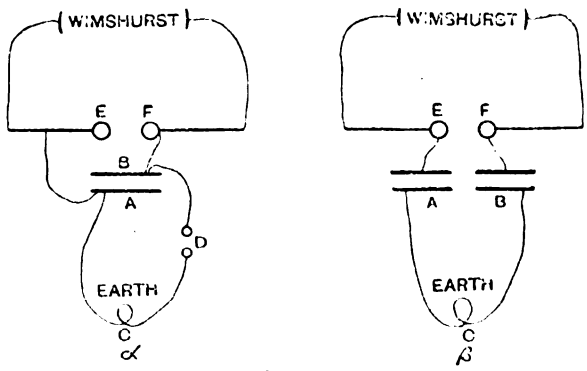

FIG. 1.

Before proceeding to describe the appearance presented by the discharge, I will mention one or two points which may prove useful to any one who wishes to repeat the experiments. According to my experience the discharge is more easily obtained in bulbs than in square tubes, and with a Wimshurst machine than with an induction coil. If an induction coil is used a break which will transmit a large current ought to be substituted for the ordinary vibrating one supplied with such instruments. It is essential to success that the gas in the bulbs or tubes should be quite dry and at a suitable pressure; there is a pressure at which the brilliancy of the discharge is a maximum, and as in endeavouring to get at this pressure the exhaustion may be carried too far, it is convenient to use a form of mercury pump which will allow of the easy admission of a little gas; the pattern which I have used and found to answer very well is called the Lane-Fox pattern. When any gas is introduced it should be sent through sulphuric acid to get rid of any moisture that may be in it. Owing, I think, to the pressure in ordinary incandescent lamps being very different from that at which the discharge has its maximum brilliancy, I have met with very poor success in attempts to produce these discharges in already exhausted tubes such as incandescent lamps, though I have tried a considerable number by different makers; on the other hand, the radiometers which I have tried allow the discharge to pass pretty readily, though it is interfered with by the vanes, and is not comparable in brilliancy with that obtained in home-made tubes and bulbs. I have obtained sparks easily with apparatus of the following dimensions:—two gallon jars, the outside coatings connected by a wire about two yards long, the coil consisting of three or four turns, each about 3in. in diameter. I have some bulbs which with this apparatus will give a bright discharge when the distance between the terminals of the Wimshurst is only $\frac{1}{4}$in.; these are,

* Abstract from the *Phil. Mag.*, October, 1891.

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however, exceptionally good; it more frequently takes a spark an inch or an inch and a half long to produce the discharge.

I find that Hittorf in Wiedemann's *Annalen*, XXI., p. 138, describes the light produced in a tube round which the wire connecting the coatings of a Leyden jar is twisted; the luminosity in Hittorf's experiments seems to have filled the tube, and not, as in the experiments described in this Paper, been confined to a ring. It seems possible that the difference in the appearance in the tubes may have been due to the existence of an electrostatic action in Hittorf's experiments, the primary coil getting raised to a high potential before the discharge of the jar, and inducing a distribution of electricity over the inside of the glass of the tube; on the passage of the spark the potential of the primary coil will fall, and the electricity on the glass redistribute itself; to effect this redistribution it may pass through the rarefied gas in the discharge tube and produce luminosity.

In my experiments I took two precautions against this effect; in the first place I connected the primary coil to earth, so that its potential before discharge took place was unaltered, and as an additional precaution I separated the discharge tube from the primary by a cage made of blotting paper moistened with dilute acid; the wet blotting paper is a sufficiently good conductor to screen off any purely electrostatic effects, but not a good enough one to interfere to an appreciable extent with the electromotive forces arising from rapidly alternating currents. In this way we can screen off any electrostatic effects due to causes which operate before the electrical oscillations in the jars begin; when once these have commenced, there ought not, I think, to be any separation of the electromotive forces into two parts, one being called electrostatic, the other electrodynamic. As this is a point on which it is desirable to avoid any misunderstanding, I hope to be excused if I treat it at some length. (The author then discusses the mathematical treatment of the phenomena of the "Electro-magnetic Field.")

We may thus regard the distinction between electrostatic and electro-magnetic electromotive forces as one introduced for convenience of analysis rather than as having any physical reality. The only difference which I think could be made from a physical point

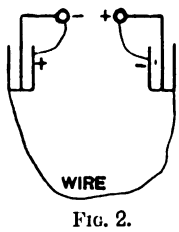

Fig. 2.

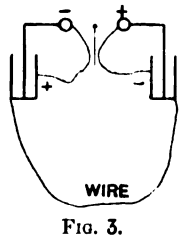

Fig. 3.

of view would be to define those effects as electrostatic which are due to tubes of electrostatic induction having free ends, and to confine the term electro-magnetic to the effects produced by closed endless tubes. It is only, however, when the electromotive forces are produced exclusively by the motion of magnets that all the tubes are closed; whenever batteries or condensers are used, open tubes are present in the field.

It will be useful to consider here the disposition and motion of the tubes of electrostatic induction in the arrangement used to produce these electrodeless discharges. We shall take the case where two jars are used, as in β (Fig. 1), as being the more symmetrical.

Just before the discharge of the jar, the tubes of electrostatic induction will be arranged somewhat as follows:—There will be some tubes stretching from one terminal of the electric machine to the other; others will go from the terminals to neighbouring conductors, the table on which the machine is placed, the floor and walls of the room, &c. The great majority of the tubes will, however, be short tubes passing through the glass between the coatings of the jars. Let us now consider the behaviour of two of these tubes, one from the jar A, the other from B, when a spark passes between the terminals of the machine. Whilst the spark is passing these may be regarded as connected by a conductor; the tubes which originally stretched between them now contract, the repulsion they exerted on the surrounding tubes is destroyed so that these now crowd into the space between the terminals, the two short tubes under consideration now taking somewhat the form shown in Fig. 2. These tubes being of opposite sign tend to run together; they do so until they meet as in Fig. 3, when the tubes break up as in Fig. 4, the upper portion running into the spark-gap, where it contracts, while the lower portion rushes through the dielectric to discharge itself into the wire connecting the coatings of the jars, an intermediate position being shown in Fig. 5. These tubes while rushing through the dielectric produce, as already stated, magnetic forces; some of them on their way to the discharging wire will pass through the discharge-tube; if they congregate there in sufficient density, discharge will take place through the rarefied gas.

The discharge of the jar is oscillatory, and we have only followed the motion of the tubes during a part of the oscillation; when, however, this tube enters the wire between the jars a tube of opposite kind emerges from it; the same thing happens when the other portion enters the spark-gap. These go through the same processes as the tubes we have followed, but in the reverse order, until we get again two short tubes in the jars, but opposite in sign to the original ones; the process is then repeated and so on as long as the vibrations last.

In order to see what are the most advantageous dimensions to give to our apparatus, let us consider on what the maximum electro-motive force in the secondary depends. Let us take the case of a condenser of capacity C discharging through a circuit whose coefficient of self-induction is L; then, if the potential difference between the plates of the condenser is initially V_0, the current γ at the time t is (supposing as a very rough approximation that there is no decay in the vibrations) given by the equations

$$\gamma = \frac{C V_0}{\sqrt{LC}} \sin \frac{t}{\sqrt{LC}}.$$

The rate of variation of this, $\dot{\gamma}$, is therefore

$$\frac{V_0}{L} \cos \frac{t}{\sqrt{LC}}.$$

So that if M is the coefficient of self-induction between the primary and a secondary circuit, the maximum electromotive force round the secondary is $M V_0 / L$, which for a given spark-length is independent of the capacity of the condenser. In practice it is advisable, however, to have as much energy in the jars to start with as possible, and better results are got with large jars than with small ones. Using a six-plate Wimshurst machine I got very good results with two "gallon jars;" with a large induction-coil the best results were got with two "pint and a-half jars."

The best number of turns to use in the primary coil C depends upon the size of the leads; if all the circuit were available for this coil one turn would give the largest electromotive force,

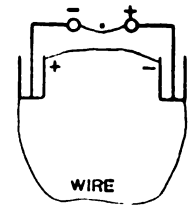

Fig. 4.

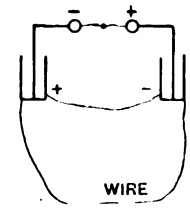

Fig. 5.

because though for a given rate of change of the current in the primary the effect on the secondary increases with the number of turns, the rate of change of the current varies inversely as the self-induction of the primary, so that if all the circuit is in the coil C, since an increase in the number of turns will increase the self-induction of the circuit faster than the mutual induction, it will diminish the electromotive force round the secondary. In practice, however, it is not possible to have the whole of the wire connecting the coatings of the jar in the coil C; and in this case an increase in the number of turns may increase the mutual induction more than the self-induction, and so be advantageous. The best result will be obtained when the self-induction in the coil C is equal to that of the remainder of the circuit. It is very easy to find by actual trial whether the addition of an extra turn of wire is beneficial or the reverse. The brightness of the discharge depends upon the time of the electrical oscillations as well as upon the magnitude of the electromotive force. Thus, in an experiment to be described later, the brilliancy of the discharge was increased by putting self-induction in the leads which, though it diminished the intensity of the electromotive force, increased the time-constant of the system. When the discharge-tube was square, and the coil C had also to be square, it was found most convenient to make it of glass tubing bent into the required form, and filled with mercury. When, however, the discharge was required in a bulb, the primary coil was made of thick gutta-percha-covered copper wire wound round a beaker just large enough to receive the exhausted bulb. There is sometimes considerable difficulty in getting the first discharge to pass through the bulb, though when it has once been started other discharges follow with much less difficulty. The same effect occurs with ordinary sparks. It seems to be due to the splitting up of the molecules by the first discharge; some of the atoms are left uncombined, and so ready to conduct the discharge, or else when they recombine they form compounds of smaller electric strength than the original gas. When the discharge was loath to start, I found the most effectual way of inducing it to do so was to pull the terminals of the Wimshurst far apart, and then, after the jars had got fully charged, to

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push the terminals suddenly together. In this way a long spark is obtained, which, if the pressure of the gas is such that any discharge is possible, with the means at our disposal, will generally start the discharge.

Appearance of the Discharge.

Let us suppose that we have either a square tube placed outside a square primary or a bulb placed inside a circular coil of wire, and that we gradually exhaust the discharge-tube, the jars sparking all the time. At first nothing at all is to be seen in the secondary, but when the exhaustion has proceeded until the pressure has fallen to a millimetre or thereabouts, a thin thread of reddish light is seen to go round the tube situated near to but not touching the side of the tube turned towards the primary. As the exhaustion proceeds still further, the brightness of this thread rapidly increases, as well as its thickness ; it also changes its colour, losing its red tinge and becoming white. On continuing the exhaustion the luminosity attains a maximum, and the discharge passes as an exceedingly bright and well-defined ring. On continuing the exhaustion, the luminosity begins to diminish until, when an exceedingly good vacuum is reached, no discharge at all passes. The pressure at which the luminosity is a maximum is very much less than that at which the electric strength of the gas is a minimum in a tube provided with electrodes and comparable in size to the bulb. The pressure at which the discharge stops is exceedingly low, and it requires long-continued pumping to reach this stage. We see from these results that the difficulty which is experienced in getting the discharge to pass through an ordinary vacuum-tube when the pressure is very low is not altogether due to the difficulty of getting the electricity from the electrodes into the gas, but that it also occurs in tubes without electrodes, though in this case the critical pressure is very much lower than when there are electrodes. In other words, we see that as the state of the bulb approaches that of a perfect vacuum its insulating power becomes stronger and stronger. This result is confirmed by several other experiments of a different kind, which will be described later.

The discharge presents a perfectly continuous appearance, with no sign of striation, of which I have never observed any trace on any of these discharges, though I must have observed many thousands of them under widely different conditions.

(To be continued.)

EXPERIMENTS WITH HIGH-TENSION CURRENTS.*

It is almost impossible to convey by words any idea of the visible phenomena accompanying the efforts of a 40,000 volt current to bridge an open space, but we will attempt a description of what we saw one evening last week. Upon a table there was fixed an electrode, some 3in. in diameter, connected to one terminal of a transformer. Over it there was mounted a large sheet of glass 3 millimetres thick, and above the glass there was a second electrode terminating in a sharp point, the distance between the electrodes being 3 centimetres. When the current was turned on to the primary coil of the transformer there first appeared a purple haze at the upper electrode, streaming towards the glass ; as the current increased this haze grew in fulness and definition, and began to throw out feelers which darted outwards, and as quickly withdrew. As the electromotive force augmented still further these feelers gathered power until they beat themselves violently on the glass, as if they would force themselves through it in their mad desire to reach the other electrode. The whole space below the pointed conductor became alive with them, and exhibited a mass of leaping, crackling threads of purple fire, which writhed and twisted in impotent attempts to burst through the barrier, and failing that, spread themselves along its surface endeavouring to rush over its edges, and so reach their goal by a circuitous route. But this was beyond their strength until the electromotive force approached 45,000 volts, when suddenly the entire appearance was changed. The current overleapt the edges of the plate and flowed completely round it in all directions. At that moment the intense purple colour of the spark disappeared, and was replaced by white light of the greatest brilliancy, which surged and scintillated in a way that produced acute fatigue of the eyes in an extraordinarily short time. Although steadier than before, the discharge still kept up its spark-like character, enfolding the glass plate in gleaming coruscations, which glistened and flashed until the spectators were fain to turn away their bedazzled gaze.

A change in the arrangement was then made. The upper pointed electrode was replaced by a brass disc 3in. in diameter. This was laid over the surface of the glass plate with three very thin washers of vulcanite intervening between the two. The current was then turned on, in the same gradual manner as before. The space between the two discs immediately filled with purple light, which had sufficient motion in it to recall the flame of a Bunsen burner, spread out under the bottom of a beaker. Sparks then began to appear at the edges, and, as they gathered strength, to radiate a little beyond them. Gradually they became streamers stretching out along the surface of the plate, in curved fanciful forms, which twined and twisted and weaved themselves into a glistening filagree, compared by an imaginative spectator to an agonised Japanese chrysanthemum. This experiment had not the brilliant refulgence of the one that preceded it, but was characterised by a quivering irradiation which writhed and tossed like a bird beating itself at the bars of its cage. In spite of its less formidable appearance, however, it proved destructive to the glass, which presently flew in pieces with a crash. Several sheets were tried in succession, but each was pierced and broken, and allowed the current to attain its object of flowing directly from one electrode to the other.

The last demonstration showed an arc under a pressure of 44,000 volts. When the electrodes approached to within 5in. the arc established itself, but instead of the flames bridging the space they streamed out in two thin tongues at right angles to the electrodes, and parallel to each other. If the electrodes were pushed nearer together the flames deserted their extremities and wandered back along their stems, evidently repelling each other. The light produced was, of course, very small indeed.

In conclusion, we may add that the voltage was reached by two transformations. An 80-volt current was first raised to 2,000 volts by one of Siemens' cable transformers, consisting of a long core of wire rope, composed of soft iron wires covered with a layer of specially prepared insulating material, around which are wound two insulated conductors, forming one the primary and the other the secondary circuit of the transformer. The secondary current was then raised to 45,000 volts by a transformer of the usual type.

* From *Engineering*, October 30, 1891.

LEGAL INTELLIGENCE.

Muirhead v. the Debenture Guarantee and Investment Company (Limited).

The plaintiff in this action, which came before Mr. Justice Denman and a Special Jury in the Queen's Bench Division on Wednesday last, alleged that in April, 1889, he introduced to the defendants certain business with the St. James's and Pall Mall Electric Lighting Company, who required capital for the extension of their operations. The plaintiff sued for commission upon these transactions, and the defendants denied their liability, alleging that the business did not come to them through the instrumentality of the plaintiff. Some evidence having been given, an arrangement was come to, and there was judgment for the plaintiff for £1,200, but without costs.

CORRESPONDENCE.

THEORY OF THE WIMSHURST MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

Monsieur : En réponse à votre note (p. 599) : "The theory of M. Pellissier is very similar to that given by Prof. Thompson," voici en quoi, surtout, cette théorie diffère de celle que j'ai présentée :

M. Thompson suppose que si A_1 (voyez le schema, p. 604) est (+), par son influence B_1 deviendra (−) A B_5 (+) ; cela ne peut être puisque $\beta\beta_1$ n'est pas isolé ; B_1 seul s'électrise ; la charge de B_5 provient d'une autre cause.

La théorie du savant professeur n'explique donc pas la distribution de l'électricité sur les plateaux ; c'est pourtant le point capital puisque l'accroissement des charges en est le résultat.

Agréez, Monsieur, l'assurance de mes sentiments très distingués,

Paris, 31 Octobre, 1891. G. Pellissier.

[We give the remarks of our esteemed correspondent in his own words, as we do not consider that the fact to which he alludes is inconsistent with the criticism we made. Whether $\beta\beta_1$ is insulated or not, any theory which accounts for the negative charge on B_1 will also account for the positive charge of B_5. We, however, agree that M. Pellissier's explanation of the growth of the charge is novel.—Ed. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

Sir : In reply to M. Pellissier, it seems to me that the growth of the charges is explained very well according to my

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theory without the intervention of the conductor $\beta\beta_1$; since the lower half of the machine is only a reduplication (with a change of signs) of the upper half. Each half can charge itself.—I am, &c., SILVANUS P. THOMPSON.

London, November 4, 1891.

ACCIDENT AT CHELMSFORD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The accident which recently occurred at Chelmsford, and which has been somewhat widely reported, is interesting in one respect that it shows that the use of overhead wires may in some cases increase the safety of the public instead of being dangerous, as has been so often stated by their opponents. A runaway omnibus passing through the narrow street which leads to the station came in contact with one of our arc lamp-posts with such violence as to break off an exceedingly massive casting at the ground line. If the wires had been underground the pole would have fallen into the street and probably caused serious damage. As it was, although broken short off, it was held upright by the system of overhead conductors attached to it, and no damage was done to anything but the arc lamp itself.—We are, &c.,

CROMPTON & Co.

Mansion House Buildings, London, E.C.,
November 2, 1891.

SAX'S COMMUNICATOR FOR CARRIAGES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your notice *re* my patent communicator for carriages, cabs, &c., in your current issue you state, "the accumulators used last for about 15 hours," without further mentioning the electric light fitted in the same vehicles, so that that remark would appear to refer to the indicators, which of course is not the case.

Could you kindly correct this in the next number?—I am, Sir, &c., JULIUS SAX.

7, Ridgmount-street, Store-street, London, W.C.,
November 3, 1891.

CLOSED CONDUITS FOR ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of October 30th you publish a letter in which the writer makes a general claim to the invention of closed conduits for electric tramways some eight years ago, and you add an editorial note calculated to convey the impression that the whole ground had been covered previously by yet another inventor. A similar claim having been made by others in the daily press I felt called upon to address a few words in reply; and as my letter, which appeared in the daily press this week, is equally applicable as an answer to your correspondent, I trust you will kindly insert the same in your next issue.—I am, Sir, &c., JOHN GORDON.

The Gordon Electric Traction Syndicate (Limited),
49, Greenwich-road, S.E., Nov. 3, 1891.

SIR: In a recent issue of your journal Messrs. Foote and von Buch address a letter to you in which they assert, without adducing a single iota of evidence, that "the principle of my method of supplying electricity to tramway rails was protected by several English inventors long before Mr. Gordon," and single out Mr. Lineff, Mr. Wynne, and Messrs. Ayrton and Perry.

It is with considerable reluctance that I beg to trespass upon your valuable space, as the readers of a daily journal are not the judges who have to decide a question of priority of invention. On the other hand, as the public desirous of investing capital in any promising scheme are apt to be misled and their minds unsettled by such unwarrantable statements as those contained in the letter above referred to, I think that I owe it to myself and my supporters to contradict these statements.

In the first place a "principle" cannot be protected by patent law. Mr. Lineff and myself, in common with everyone else who has given attention to the closed-conduit systems, use an interrupted surface conductor as the medium through which the current is conveyed from the main conductor to the motor on the car. But here the resemblance between the two systems ends. The means by which the desired object is accomplished are totally different, and I am certain that Mr. Lineff himself would be the last to assert that my system resembled or infringed his.

The Wynne system involves electro-magnetic mechanisms, placed in water-tight boxes under the roadway, *every eight or nine feet* or so, and the employment of the main current for operating these mechanisms; whereas two of the main features of the Gordon system are the absence of moving parts and mechanism under the roadway and the employment of a shunt current only for working the electro-magnetic distributors, which put the sections of the interrupted conductor into and out of connection with the main conductor. These are placed under the pavement about *100 yards apart* in such a way that they can be readily examined, tested, and, when necessary, repaired, without interference with the traffic or disturbing the roadway communication between these and the various sections of the divided centre rail is effected by means of service conductors, one for each section.

Without wishing in the slightest degree to detract from the praises due to Messrs. Ayrton and Perry, "whose names have been," as mentioned in Messrs. Foote and von Buch's letter, "so honourably connected with the very earliest endeavours to apply electricity to the propulsion of railways and tramways," I would beg to submit that the fact that after the lapse of ten years the invention for the propulsion of tramcars on an ordinary thoroughfare claimed for Messrs. Ayrton and Perry has got no further than the paper stage, is *primâ facie* evidence that the special system referred to is impracticable. It is one thing to describe a beautiful and ingenious system in a patent specification, but it is another thing to describe and protect a system and then work out that system practically according to that description. The time since we began to put the Gordon system to a practical test must be counted by months instead of years. A full-gauge line, 70 yards long, has been constructed at the works of Messrs. Merryweather and Sons, fire engine and tramway engineers, Greenwich, and the results have been so favourable that already negotiations are on foot for the construction of a line of considerable mileage on the Gordon system.

With regard to the reported wonderful invention of Mr. Edison for tramcar propulsion, I think that the article published in the *Daily Oracle* for October 24th, and my letter addressed to and published in the same organ for October 29th, as well as the comments of the technical press, will set at rest the minds of those who have been agitated by this American "boom." Trusting that the daily growing interest in this subject will be sufficient excuse for trespassing so much on your valuable space,—I am, &c.,

The Gordon Electric Traction Syndicate (Limited), JOHN GORDON.
49, Greenwich-road, S.E.

[Mr. Gordon's idea was described in *The Electrician*, Vol. XXVII., p. 281. The length of the conductors is about seven times that of the track, and it is proposed to use 7/18s. The inventor's estimate for adapting an existing tramway to his system is about £2,000 per mile. More details may be found in the patent specification, No. 6,083, 1890 (price 1s. 1d.). No subsequent improvement appears to have been patented. Profs. Ayrton and Perry proposed to place one magnet at a time under the lines; and Mr. Wynne suggested putting them in boxes sunk alongside the track, if necessary under the pavement, Mr. Gordon groups twenty or thirty together in one box. He first describes an arrangement with a rotating switch-arm pulled round by a number of successive magnets; but towards the end of the final specification he makes this rather amusing statement, "As the result of recent experiments (and having regard to the obligation imposed upon me to disclose the best means with which I am acquainted for carrying out my invention) I prefer to arrange the distributing apparatus in such a manner that the centrally pivoted revolving arm previously described may be dispensed with." He then describes the use of ordinary magnets for the same purpose. We cannot see the advantage of continuing a discussion on a system which has only been tried on 70 yards in the maker's works, but shall be glad to describe it fully after a few miles of line have been in public operation for a few months.—ED. *E.*]

HARTMANN AND BRAUN INSTRUMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We are much obliged to you for the care and attention you have given our instruments in the current number of your esteemed paper, on pages 705, 711, 717, and 718; and we take this opportunity to ask you to be good enough to give us space for making some small corrections. Fig. 1 is an ordinary Kohlrausch ampere-meter *without* mercury. Fig. 2 your type-setter has placed upside down. German scientific instruments are by no means in an undeveloped condition, as you remark. Numbers of your readers who saw Hartmann and Braun's pavilion at the Frankfort Exhibition will hardly have come away with that impression. The clock shape has long ago gained pre-eminence in Germany, as it has in England. We should also like to point out that Fig. 3, which

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HARTMANN AND BRAUN'S INSTRUMENTS.

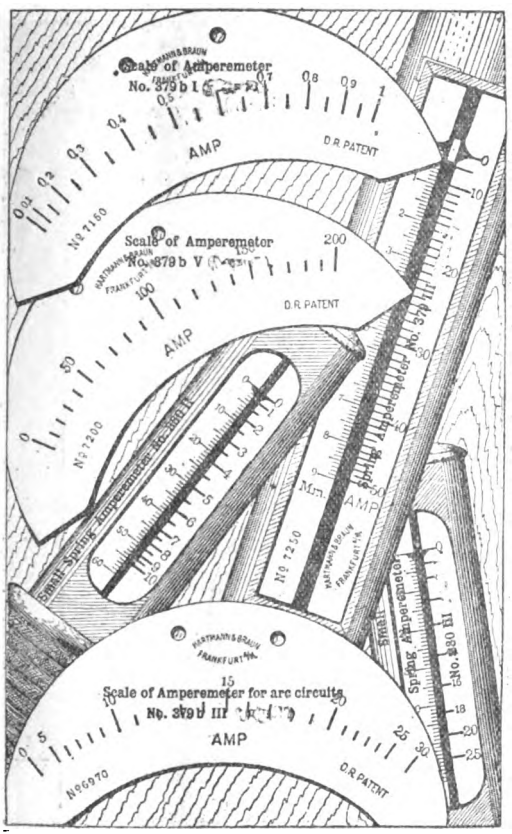

Diagram of Ampere-meter Scales (half full size).

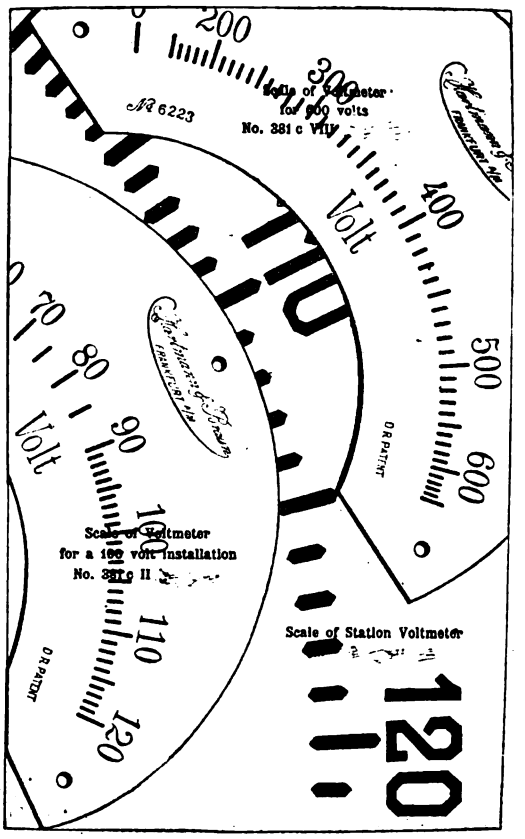

Diagram of Voltmeter Scales (half full size).

represents any instrument which may have been ready at the time when the wood engraver was called in, by no means infers that these instruments can only be made like this sketch, with—as you say—a non-uniform scale. It is the fact that by our being able to produce any scale we may be asked for, either uniform throughout or uniform in any part, or in wide readings at any given point, that our instruments (volt and ampere-meters) find such universal favour, and are so largely in use in England as well as elsewhere. Allow us to hand you herewith reduced illustrations of some of our volt and ampere-meter scales, which will at once convince you that the adaptability of our construction of instruments to anything we are asked for is our great point, apart from the accuracy everyone expects and finds in high-class German scientific instruments.—We are, Sir, &c.,

HARTMANN AND BRAUN.
London Office: O. Berend and Co.

[This matter is referred to in our Editorial columns.—ED. *E.*]

THE NEW GERMAN PATENT LAW.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It will be of interest to your readers to know that a new Patent Law has recently (October 1, 1891) come into force in Germany, whereby important changes of considerable importance to inventors are effected.

According to the provisions of the present law, an invention is considered new if at the date of filing the application for patent it has not been so described in public prints within the last century, or so publicly employed in the German Empire that the use of the same by persons skilled in the art appears possible. The official foreign patent specifications are only considered equal to public prints after the lapse of three months from the date of publication, in so far as the patent is applied for by the foreign patentee or his legal successor. This exception only refers to the official publications of those States in which (according to an official publication) reciprocity is guaranteed.

It will be remembered that hitherto an invention was not considered new in Germany if it had been already described in any printed publication whatever, or publicly used in Germany at the date of the application for patent. Also, if a patent is granted for a process, its scope is extended to the direct products of the process. A very much more complete and satisfactory system of examination of applications is provided, a permanent staff being appointed, and each examiner is confined to his own department; further, it is enacted that where an applicant appeals from the decisions of the application or annulment departments, no member who took part in the decision appealed against may take part in the decision on such appeal.

This is certainly a step in the right direction, and it appears probable that the final decisions will, at any rate, be less unfair than hitherto under the old system of non-permanent or "casual" examiners, who reconsidered their own decisions on appeal with an obvious result.

Another new departure is a "Law for the Protection of Useful Models." It is a most important supplement to the new Patent Law, which latter it in some respects supersedes.

All kinds of tools and implements which cannot be patented can be protected by this law—even the subjects of refused patent applications can now in many cases be protected. A most important provision is that applications are accepted without examination. The protection lasts six years, and promises to prove of value for all kinds of small inventions not perhaps worth patenting fully.—I am, &c.,

J. C. CHAPMAN (Chartered Patent Agent).

70, Chancery-lane, London, W.C.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—An extraordinary general meeting of this Company was held yesterday (Thursday) at Winchester House, Sir David Salomons, Bart., in the chair. The following resolution was carried unanimously:—"*That the special resolution which was passed at the ordinary general meeting of the Company, held on the 15th day of October, 1891, as follows:—That Article No. 13 of the Company's Articles of Association be altered by inserting after the words 'each call' at the end of the fourth line, the following:—'and that no call shall exceed one-fifth of the nominal amount of a share, or be made payable within two months after the last preceding call was payable,' be and is hereby confirmed.* A fuller account of this meeting will appear in our next issue.

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS INVITED.—The Midland Railway Company desire tenders for the supply of general stores, including (No. 10) telegraph instruments, wire, &c. Forms of tender may be obtained of Mr. Pettifor, General Stores Department, Derby; and tenders are to reach the Secretary of the General Stores Committee, Midland Railway, Derby, by 9 a.m. on November 11th.

——— The Cheshire Lines Committee are prepared to receive tenders for the supply, during the year 1892, of stores and material, including (No. 7) telegraph materials, instruments, wire, &c. Specifications and forms of tender may be obtained from Mr. S. S. Barton, storekeeper, Cheshire Lines, Warrington; and tenders are to reach Mr. Edward Ross, secretary, London-road Station, Manchester, by 10 a.m. on November 28th.

TENDERS ACCEPTED.—The tender of the Jensen Electric Bell and Signal Company (Woodhouse and Rawson United, Limited) has been accepted by the Metropolitan Asylums Board for the maintenance in proper working order of the electrical apparatus at the Darenth Asylum and Schools, at £75 per annum.

——— The Southampton Harbour Board have accepted the tender of Mr. F. Shalders, High-street, Southampton, for supplying electric light fittings for the pier, for £575.

BRUSSELS.—The following contractors have sent in tenders for the general electric lighting plant of Brussels:—S. Z. de Ferranti (Limited), London; Crompton and Co., London; Schückert and Co., Nuremburg; Siemens and Halske, Berlin; India Rubber Company, London; Compagnie Internationale d'Electricité, Liège.

SALES BY AUCTION.—We refer our readers to our advertisement columns for particulars of sales by auction by Messrs. Wheatley Kirk, Price and Goulty, at 39, Queen-street, London, E.C., on Wednesday, the 11th inst., and following days; and at the Star Tube Works, Heneage-street, Birmingham, on Tuesday, the 17th inst., and following days.

THE FORTHCOMING ELECTRICAL EXHIBITION AT ST. PETERSBURG.—The following notice was given by the *Russkiya Viedomosty* on the 7th (19th) October last:—"Seventy foreign exhibitors have consented to participate in the next Electrical Exhibition at St. Petersburg. Mr. Edison has paid 2,000 roubles (£200) for the space which he intends to occupy at the Exhibition. Among his new inventions prominence will be given to an electrical fountain and lighthouse. The German branch of the Thomson-Houston Company exhibit an electric borer or auger for ore or stone boring." The principal object of the Exhibition is, no doubt, to push the electrical goods of the various French firms, whose manufactures are at the present time in considerable favour in St. Petersburg. A number of these companies are formed for the sale and manufacture of Edison plant, and we understand that they have succeeded in placing their manufactures almost exclusively in Moscow, and have a fair prospect of securing a similar monopoly in St. Petersburg. Electric lighting business is not very brisk in Russia just now, but what there is doing is largely in the hands of French houses.

"THE ENGINEER."—The advertisement and editorial departments of *The Engineer* have been removed to larger offices at 33, Norfolk-street, Strand, London, W.C.

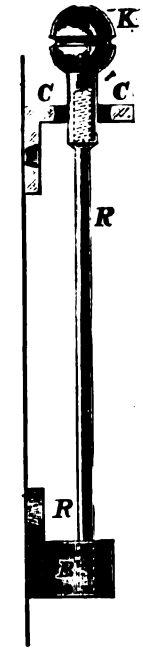
ARCHER PATENT JOINTED STONEWARE PIPES.—These pipes are being used by Messrs. J. H. Gordon and Co. (Limited) as mains for the cables to supply the electric light at the Crystal Palace.

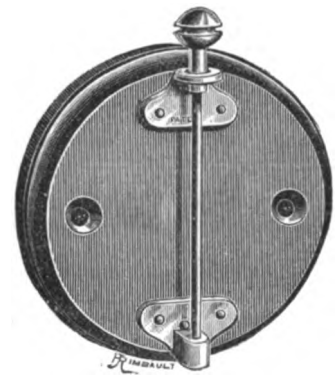
MESSRS. G. E. BELLISS AND CO.—In order to provide the necessary facilities for a rapidly increasing electrical business, Messrs. Belliss and Co. open on the 9th inst. a London office at Westminster-chambers, 9, Victoria-street, S.W., under the management of their London representative, Mr. W. Crawford.

MR. G. G. BLACKWELL.—Mr. Blackwell, of Liverpool, has appointed Messrs. Stobbs, Wilson, and Pollard, 4, Billiter-buildings, E.C., his London agents for the sale of manganese, &c.

BUSINESS CHANGE.—The business of Messrs. Cecil Wray and Co., of Bradford, has been acquired by Messrs. Andrews and Preece (Limited).

MAJOR BAGNOLD'S PATENT IMPROVED BELL-PULLS AND BELL-REPEATERS.—The ordinary push-button must be pressed in a direction at right angles to the surface of the wall or other support to which it is fixed; again, the contact made is not always of the best, it is essentially a "butt" contact, and possesses little or no self-cleaning powers. It is difficult to actuate these push-pieces from any other position; flexible cord connections are also used connected to "pear" pushes, but these are seriously liable to derangement. A diagram and a view of the bell-pull are shown in Fig. 1; a rod of steel, RR, is set vertically with its lower end firmly fixed into a brass block, B; on its upper end is screwed a brass knob K, the shank of which passes through a brass ring CC; the conducting wires are attached to B and C. A slight pressure applied to K in almost any direction other than in that of the axis of the rod RR, will deflect that rod and cause the shank of the knob to touch the ring CC, and make the necessary contact. This contact needs no silvering or platinizing, as the knob can at any time be given a circular motion which will clean the contact surfaces and ensure the establishment of the circuit. If it be desired to actuate this contact-piece from a distance it is only necessary to tie a fine cord round the horizontal groove on knob K, and this cord can be led





FIGS. 1.

off in any required direction such as to a bed, a chair, or a dinner table. This bell-pull can also be conveniently combined with a sound repeater. The repeater is shown in Fig. 2 without the

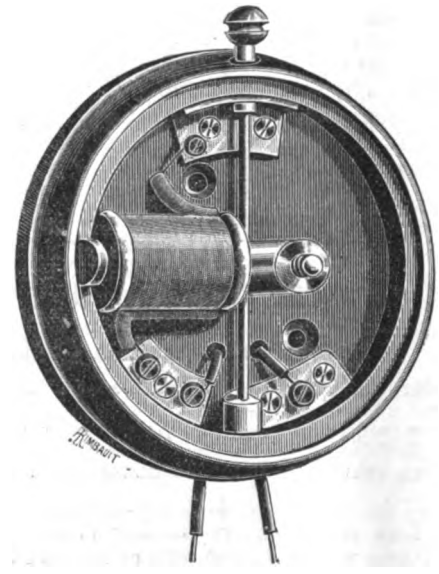


FIG. 2.

dome. When the latter is screwed on, one pole of the electromagnet is presented to the side of the bell; as soon as the contact is closed and the circuit is intermittently interrupted at the distant "chattering" bell, the bell dome of the repeater is set into vibration, and gives out a clear but not inconveniently loud ringing sound. These bell pulls and repeaters are the invention of Major Bagnold, and are made by Messrs. Siemens Bros

WORCESTER.—On Saturday last an effective electric lighting display was shown at Worcester Cathedral to celebrate the return of the Earl and Countess of Dudley. One of the large search lights from the Naval Exhibition was placed on the roof of the Cathedral, added to which four large arc lamps were placed at other points of vantage. The work of installation was undertaken

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by the British Electric Installation Company, and was under the superintendence of Mr. Morgan Williams, their consulting engineer. Mr. Ronald A. Scott carried out the erection of the plant at the Cathedral.

MESSRS. ERNEST SCOTT AND MOUNTAIN (LIMITED).—This firm inform us that the Earl of Ellesmere has decided to light by electricity the large private house and training establishment now built on his estate at Newmarket, and that the contract has been entrusted to them. The installation is to consist of a 30 I.H.P. horizontal engine, which will be used in driving a specially wound "Tyne" dynamo, supplying current to a set of accumulators capable of running 100 16-candle-power lamps for 10 hours, or the dynamo will supply 200 lamps direct. The engine power will also be utilised for pumping, chaff-cutting, &c.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

September 24, 1891.

16,205. M. C. GREENHILL and J. R. SHEARER. London. A meter for telephonic and other purposes.

16,250. R. HAMMOND and C. J. HALL. London. Improvements in dynamo machines.

16,270. W. P. THOMPSON. Liverpool. Improvements in or appertaining to accumulators for the storage of electric currents. (E. Correns, Germany).

September 25, 1891.

16,293. W. E. HEYS. Manchester. Improvements in the method of and in the means for propelling ships and other vessels electrically. (J. J. Heilmann and F. Drouin, France).

16,300. C. S. SNELL and WOODHOUSE and RAWSON UNITED (Limited). London. Improvements relating to electrical fittings.

16,312. D. G. SHEPHARD and N. G. THOMPSON. London. Improvements in electric crane hoists &c.

SPECIFICATIONS PUBLISHED.

1890.

15,828. KING. Dynamo machines. (Price 6d.)

18,791. IMRAY (BAPTISTA). Fixing telegraph wires to insulators. (Price 6d.)

1891.

10,347. FITZPATRICK. Electric battery. (Price 6d.)

12,070. SCHÖLLER AND ANOTHER. Reciprocating the anchor of an electric apparatus. (Price 6d.)

12,540. CUENOD AND OTHERS. Dynamo-electric machines. (Price 6d.)

12,541. CUÉNOD AND OTHERS. Dynamo-electric machines, &c. (Price 6d.)

13,171. CRIGGAL AND OTHERS. Incandescent electric lamps. (Price 6d.)

13,269. GIMINGHAM. Electrical glow lamps. (Price 6d.)

13,753. CLARK (NOYES). Telegraphic call boxes. (Price 6d.)

13,809. HUGHES (LEGRAND). Covering wire conductors with leather. (Price 11d.)

13,917. SMITH. Telegraphing. (Price 8d.)

14,295. SPITTLE. Protecting electric installations from lightning, etc. (Price 6d.)

COMPANIES' MEETINGS & REPORTS.

The Monte Video Telephone Company (Limited).

The annual ordinary general meeting of this Company was held at the Company's offices, 25, Abchurch-lane, E.C., on the 30th ult., under the presidency of Mr. Arthur Holland.

The SECRETARY (Mr. E. Johnson) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said the accounts for the present year, as compared with those of last year, showed that the receipts from subscriptions had diminished by £2,604, while the London expenses had increased by £75, and the expenses in Monte Video by £1,051. To meet bad debts last year the Company had written off £660, and the amount written off this year on the same account was £852. There was also a loss of £332 by the defalcation of the Company's collector in Monte Video. The consequence was that the net profits of the Company, as compared with last year, had diminished by £5,381. It had caused the Directors considerable regret to have to present a report showing so large a diminution of profit; but he thought, when the shareholders heard the explanation the Directors had to offer, they would be satisfied that no more could have been done to obviate that result. In the first place, the increase of £75 in the London expenses had arisen from the fact that they had been debited with £102 for interest on the money borrowed last year to pay the dividend. The other items of London expenditure had been reduced by small amounts. As regarded the increase of £1,051 in the expenses at Monte Video, he found that wages and salaries there had been reduced by £61, and as a result of steps taken during the past year, they would be considerably reduced in the current year. The rent in Monte Video had increased by £70, owing to the failure of a tenant occupying part of the Company's buildings to pay his rent. That tenant had left and they had to find another. The cost of materials had gone up £766—a large amount. The Company had also been put to considerable expense by reason of the new Municipality of Monte Video compelling them to remove posts from certain of the streets, and a considerable sum of money had to be expended in fresh wires and cables. In explanation, he added, that there was a stipulation in the original concessions to the Company that posts might be erected in roads, but not in streets; and that consequently as the roads became streets by the extension of the town, the removal of the posts originally put up became necessary. Concerning the small items of expenditure, he stated that travelling expenses were about £36 more than in the previous year; stationery was about the same, and there was a slight increase in the expenditure on freights. Addressing himself to the question of bad debts, he acknowledged that this was a serious amount to meet. In the year before last £245 was written off on this account; and last year, owing to the depressed state of all business in Monte Video, the Company had been unable to recover £660 of outstanding bad debts; while this year the amount had risen still more, and they were compelled to write off £852. When intelligence was first received of the defalcation of the collector in Monte Video, the Directors were naturally very much surprised that the manager of the Company there should have permitted such a thing to take place, because the Managing Director when he was last out there laid down certain rules which he considered sufficient to prevent any embezzlement. Further accounts received from the manager at Monte Video, however, showed that he could not have discovered the falsification of the receipts otherwise than by accident, as was eventually the case. Steps had now been taken to try to ascertain if a better system of receipts could be devised. The collector had been insured in a guarantee society for one thousand dollars, but the financial depression had so affected that society that it had gone into liquidation, and nothing could be recovered. Referring to the diminution in the receipts, he stated that the number of subscribers who had withdrawn during the last year was 507, of whom 372 had left for reasons of economy, 69 had failed, 47 had left Monte Video, 17 had gone over to the Co-operative Company, and two assigned no reason for leaving. As a set-off to the number of withdrawals, he was glad to report that 315 new paying subscribers had joined the Company. That was about the natural increase of subscribers in the course of ordinary business, and he could not but think it satisfactory to find that there was such a large accession of subscribers in spite of the depressed state of things in Monte Video. He thought also that the accession of over 300 new subscribers, as against 400 in the previous year, tended to show the good service afforded by the system as now perfected. So far as the Directors knew, there was no better system in vogue. As regarded the balance sheet, it would be seen that £4,500 of the profit had been placed to "depreciation," practically to meet expenditure made in the past. The balance showed that the Company had spent £220,000 on capital account, and that there was a difference between the debtor and creditor side of the accounts of £1,600, against which there stood only a capital of £215,000 and a reserve of £3,000, thus leaving a deficiency of £3,600, which, with the cash in hand necessary to carry on the working of the business—£1,400—accounted for the further £4,500 which had been put to depreciation. So far as the prospects of the business were concerned, much depended upon the state of affairs in Uruguay, but he could not but think that the Company had reached "bed rock" as regarded the minimum number of subscribers. The accounts from the agricultural and pastoral districts of Uruguay were favourable for the coming season; and as the welfare of the towns on the other side of the River Plate depended upon the wool-clip and harvest in those districts, it must be expected that their prosperity would re-act upon the towns. Then the Company would begin to see that their number of sound, paying subscribers increased. Another item that would affect the number of subscribers was the contemplated reduction in the customs and taxation of the country by reason of the new arrangements which the Uruguayan Government was making with its bondholders on this side. If there is a certain relief from taxation the amount saved ought to be put into business, and help trade to flourish. He thought he had very fully stated the whole situation, but would add that the manager at Monte Video had been compelled to use great tact to avoid coming to loggerheads with the Municipality concerning the removal of the posts. They had now, however, come to fair terms. With reference to certain losses by the failure of the National Bank of Monte Video, he stated that those were due to the fact that the manager at Monte Video had to accept notes of that Bank in payment from subscribers, and the loss thus entailed went to swell the bad debts. The Directors expected that the next year would show a diminution of the expenses in London and Monte Video of about £200, and he hoped that next year they would be able to present a much more satisfactory result. He concluded by moving the adoption of the report and statement of accounts.

Mr. THOS. D. PETERS formally seconded.

Mr. BALFOUR said the first idea one would entertain after reading this report would be to ask whether it had been composed by serious men. Referring to an expression in the report, he asked whether the Directors and managers considered it matter for congratulation that whereas the Company three years ago had a monopoly of the telephonic business in Monte Video, there now existed a rival company with 1,000 subscribers. Was it, he asked further, cause for congratulation that the defalcations of the collector had extended over some time without detection? Considering the meagre amount of cash in hand at Monte Video, he inquired whether it was thought possible that the embezzlement could have gone on if the manager there had balanced up his books. He asked also, if it was considered cause for congratulation that the Monte Video manager had allowed things to come to such a pass with the National Bank. Mr. Balfour then entered into a comparison of the balance sheets for the last three years, showing a diminution in the amount of receipts

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with an increase in expenditure, and concluded by expressing the opinion that the Board did not recognise the gravity of the situation.

The MANAGING DIRECTOR (Mr. Edward F. Powers) thought it was incumbent on him to answer Mr. Balfour, in view of the fact that he held in the Company the position of Managing Director. At the same time he regretted that that gentleman had seen fit, after the very careful and lucid exposition of the position of the Company which he (the speaker) had already given to him, that he should again ask that position to be made clear. Mr. Balfour had concluded his remarks by asking the Directors if they could realise and appreciate the grave position which they were in. But he would like to ask Mr. Balfour whether, in analyzing and criticizing the report, he understood the precise position of affairs in Monte Video. He thought that if that gentleman did so, he would have more of the spirit which prompted the Board to say that it had more cause for congratulation rather than for condemnation. When he reviewed the position in Monte Video—the disasters which had occurred there—during the last year, the failure of the National Bank, its reorganisation, and its second failure, the poverty of the people at large, in short the utter stagnation of all commercial and industrial interests, crippling political affairs, and ending in revolutions, not to speak of other obstacles militating against the conduct of business, he thought they were to be congratulated that they had so much as they possessed. He said this with no superficial idea of the position, but as a man connected with the River Plate; not in offices in Throgmorton-street or on the Stock Exchange, but as one who had lived there and had some practical as well as theoretical knowledge of the Company's business; and he would not withdraw one word of their congratulations. The next point that Mr. Balfour brought to their notice was that the rival companies had 1,000 subscribers. They had 1,000 subscribers before he concluded the transfer to this Company from the old Monte Video Telephone Company, Limited; they had 1,000 subscribers before he had the legal documents in his possession, before he registered the transfer and purchase of the Gower-Bell interest which was sold to this Company by Messrs. Quilter and Henderson, and a copy of which he possessed for the inspection of any person making application. As Managing Director of the Company he had been in negotiation with the opposition Company for the purpose of finding out what their position was. He had been in negotiation with the President and one of the largest shareholders of the property for the purpose of arriving at a common understanding in regard to the working of the two interests; and he could only say that their position was of such an unknown quantity, that it was so doubtful in their own minds, that the President refused to go on with the negotiations in London because of the restrictions in his power of attorney, and actually passed through London without seeing him. Whether the existence of the other company in Monte Video was an annoyance or hindrance to their business he did not know. He presumed that it relatively stood in the position in Monte Video that the Co-operative Company did in Buenos Ayres. He hoped it was no worse. The next point Mr. Balfour referred to was with regard to the defalcations. After six or seven years' experience in receiving moneys from collectors in Buenos Ayres, he had himself instituted a system for checking those men. It was the best that he could devise, but it proved not to be infallible; and the defalcations referred to arose from the fact of the subscribers to their service in Monte Video not taking care to check any receipt they got for money received by the collector in place of the prescribed form; and consequently no power on earth could have found out the defalcations. He would be very glad indeed if anyone could show him a system by which such losses could be saved. As to the National Bank notes, they were received after the failure of the Bank for the simple reason that there was no other money that they could get from the people who owed it to the Company. They had to take the notes or nothing. This might be seen on reference to the file of the manager's letters.

Mr. HENDERSON said that the Bank resumed payment on the 1st July, 1891. If they held any of the notes on the 30th June, he presumed they would be dealt with in next year's accounts.

The MANAGING DIRECTOR said that the last notes taken in by the bank were at a discount of 4 or 5 per cent., according to the best of his recollection. That was the position when those negotiations were going on. There was no power on earth could have saved the losses that they had so openly placed on the face of the accounts. They say that nobody else could have done anything else, because if the Bank of England failed to-morrow its notes would fetch exactly what they were worth, as in the case of the National Bank of Monte Video, and they had to take paper in lieu of gold, and so there was a certain loss incurred. But this course had to be adopted in order to pay their employés, &c. Mr. Balfour referred to what he believed was a comparison of the relative expenses to the income during the last few years. No doubt the figures were correct, but anybody acquainted with telephonic business must be aware that though they had a withdrawal of subscribers here and there, they could not withdraw their employés. If they lost, say 25 lines on a given road, they could not take off the young lady that handled the switchboard, because on those lines other lines existed. Unless a very large number were withdrawn they could not dispense with the men who cleared and repaired the lines. These were natural obstacles to the full and proper development of a telephonic company. They had never been solved in any other part of the world he knew of. If they could be, he could only say that he would take measures, so long as he was connected with the Company, to follow out such a system. He must say that he did not know that there was any business in Uruguay built up with English capital that was stronger in its position than theirs was. He would be very glad indeed to hear how their position could be strengthened in any shape or form. He would like to say, before concluding, with regard to certain rumours he had heard respecting the management, that the only comment he had to make on those rumours was that he held proxies representing £50,000 odd, and he had friends who had come forward to buy a large number of shares; and as a mark of the faith and belief they had in him, he thought that this was the best testimony he could bring forward.

Mr. HENDERSON said he understood there was a proposal to make a change in the management. Had it not been for that he would certainly have proposed an amendment, because, judging from experience, he was afraid of the Company having to go into liquidation. The Directors had no right whatever, according to their showing now, to pay a dividend last year.

The CHAIRMAN said he might state that the reduction of the tariff all round would be a very serious matter; but the manager in Monte Video had been empowered to consider the case of individual subscribers where it was found necessary. The increase of expenses at Monte Video was due to the Company having written off a large amount to maintenance, instead of putting it to capital account, a course recommended by the auditors. With reference to the payment of a dividend last year, he said it looked at that time as if the then prosperity of the Company would continue.

Mr. G. H. SANDFORD asked how many subscribers there were.

The CHAIRMAN said there were 1,400.

Mr. SANDFORD further asked what was the amount lost by taking the National Bank notes instead of gold.

The CHAIRMAN answered £125. He then put the motion, which was carried.

The MANAGING DIRECTOR proposed, and Mr. T. D. PETERS seconded the re-election of Mr. Holland to his seat at the Board.

The motion having been carried unanimously,

The Auditors, Messrs. Gérard Van de Linde and Son, were reappointed, on the motion of Mr. HENDERSON, seconded by Mr. THORNBURY.

Mr. SANDFORD then proposed a vote of thanks to the Chairman, which was seconded by a SHAREHOLDER, and cordially passed.

The CHAIRMAN having briefly returned thanks, the proceedings terminated.

Crompton and Company (Limited).

An extraordinary general meeting of the members of Crompton and Company (Limited) was held at the registered offices of the Company, Mansion House Buildings, Queen Victoria-street, on Tuesday last, for the purpose of considering, and if approved, of passing the resolution set out below. Mr. R. E. Crompton was in the chair.

Mr. FRANCIS R. REEVES (the Secretary) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said that the shareholders had heard the notice read, and he would now proceed to explain the reason for calling the meeting, which was, as they had stated in the notice, to increase the capital of the Company. It would be recollected that three years ago the Company was a private partnership, which from small beginnings had grown to a not inconsiderable position, and since it had been turned into a Company that growth had been continuous. They had gone on progressing by leaps and bounds, and year after year they had very much increased their percentage: they had increased it as much as 30, 40, and 50 per cent.; and now their turnover was two and a-half times what it was when it was a private firm. The calculations made at the time the Company was formed and the prospectus issued did not anticipate such a great increase, and in consequence they had already found themselves considerably crippled, and they had had to refuse good and valuable orders that had been offered to them because they had not sufficient working capital to carry them out. They had not refused, of course, all orders, but they had had to refuse those which required a considerable amount of working capital to carry them out. They had, however, done a large amount of work with the capital that they had at their disposal, and they had carried it out in a satisfactory manner, and made a good profit, which had enabled them not only to pay the full preference interest, but had left a large margin for the payment of the ordinary shares dividend in addition. They had at the present time considerable offers pending, and the Directors had come to the decision to take steps for increasing the capital of the Company, and they deemed the best way, as stated in the notice issued to the shareholders, was to issue an increase of preference capital. To give the shareholders some further idea of the advantage of ample capital in their particular business he might say that if they had plenty of capital they were able to pay absolutely cash for much of the material which they purchased, and they were not compelled to give three months' limit, whereby they lost considerable discounts. The losses they would be liable to incur in this respect would be overcome and avoided if they obtained this extra capital for which they were now asking. Personally he must say that he would not, being a large holder of ordinary shares—indeed, the ordinary shares were mainly held by the members of the old firm, himself, and Mr. Albright—have allowed the new capital to come in front of the ordinary shares for dividend unless he had felt that in making this increase the results would be increased business that would justify the step, and that they would not lose but gain in the prosperity of the business. It had been suggested to this Board that those shares might have been issued to the shareholders at a premium; but after carefully considering the matter the Board had felt it wise to divide the amount into two, and they proposed to make a first issue of 5,000 new preference shares at par, and to let the present shareholders have the advantage. Their preference shares at the present time stood at a premium—a considerable premium—in the market, and the Directors felt that it was only fair that the existing shareholders should have the benefit. As to the remainder, the Directors would consider whether they would issue them at a premium or not. Although there was a very small attendance of shareholders at that meeting, he would like to state that the Board had obtained the opinion of the general body of the shareholders by means of proxies, and they had received proxies representing more than three-fourths of the shares. He concluded by moving:—

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"That the capital of the Company be increased by the issue of 10,000 additional preference shares of £5 each, such shares to be numbered 20,001 to 30,000, inclusive, and to rank for preference or priority as regards dividends, and in the distribution of assets, and in all respects pari passu with the already existing preference shares of the Company, and the Directors are hereby authorised to issue these new shares at such times and on such terms as they may think fit."

Mr. J. F. ALBRIGHT (Director) seconded the motion. He stated that he was a very large ordinary shareholder, as the Chairman had said; but he was, like the Chairman, willing to stand aside and allow further preference capital to be placed in front of his ordinary shares, as he believed it was for the ultimate benefit of the Company, and that it would increase their trade, and that they would be able to do a larger business in consequence. He had, therefore, much pleasure in seconding the motion.

The CHAIRMAN invited discussion.

No questions were asked.

The motion was then put, and carried unanimously.

A vote of thanks to the Chairman closed the meeting.

Western and Brazilian Telegraph Company (Limited).

The following is the report of the Directors of this Company to be presented at the twenty-second ordinary general meeting of the Company to be held at Winchester House, London, E.C., on Thursday, the 12th inst., at 12 o'clock:—

The total earnings amount to £104,962 9s. 7d. as against £89,846 13s. 9d., an increase of £15,115 15s. 10d. compared with the half-year to 30th June, 1890. From the above total earnings has been deducted the sum of £11,121 4s. paid in respect of traffic receipts between March, 1889, and December, 1890, hitherto under dispute.

The working expenses amount to £38,638 10s., as against £40,509 13s. 3d., a decrease of £1,871 3s. 3d.

Including the amount brought forward from 1890 (£6,070 6s. 1d.) and the dividend received upon the shares held in the "Platino" Company to the 30th June, the balance to the credit of the revenue account is £79,781 10s. 8d., from which has to be deducted £12.866 10s. for debenture interest, and £6,233 10s. for the debenture redemption fund, leaving £60,681 10s. 8d., of which £25,000 has been placed to the reserve fund. This leaves £35,681 10s. 8d. The Directors recommend the payment of a dividend of 6s. per share, free of Income Tax, on the ordinary shares for the half-year, being at the rate of £4 per cent. per annum, carrying forward £6,470 4s. 8d. At the corresponding period last year the dividend was at the same rate.

The arrangement with the Monte Videan and Brazilian Telegraph Company, already approved by the shareholders, was completed on the 11th June, and 5,300 ordinary shares were issued in exchange for the undertaking of that Company, which has now been wound up.

The new cables between Pernambuco and Bahia, Bahia and Rio de Janeiro, and Rio de Janeiro and Santos have been satisfactorily laid by the contractors, The India Rubber Gutta Percha Telegraph Works Company (Limited). They were duly taken over, and have greatly improved the working of this Company's traffic. The section between Pernambuco and Ceara, which contained the last long length (over 200 miles) of original cable, was interrupted in March, and could not be repaired owing to the type of cable, its condition and the great depth of water. The probability of this happening has been previously referred to, and although this section has now given way it has lasted a considerable time longer than the Directors anticipated. Arrangements were therefore made to send out sufficient new cable in the "Silvertown" to restore communication, and this was successfully done in September.

The dividend warrants will be posted on the 13th November.

NEW COMPANIES, STATUTORY RETURNS, &c.

BICESTER ELECTRICITY SUPPLY COMPANY (LIMITED).—This Company was registered on November 2, 1891, with a capital of £5,000, in £5 shares, by Messrs. Inderman, Clark and Parker, 1, Devonshire terrace, Portland-place, W. It intends to carry on at Bicester the business of an Electricity Supply Company, by constructing, laying down, erecting, fixing, and carrying out the necessary cables, wires, lines, primary, secondary batteries, accumulators, lamps, &c., and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, manufacturers of and dealers in apparatus necessary for the generation, distribution, accumulation, and supply of electricity, &c. The subscribers are Messrs. F. Smith, W. Grinsley, J. W. Smith, T. W. Pankhurst, T. C. Fruch, J. Colman, and G. T. Cannon, all of Bicester. Registered without articles of association.

BLAIKIE BROTHERS (LIMITED).—This Company has been registered in Scotland, with a capital of £30,000, in £1 shares. Object:—The purchase of the business, machinery, plant, and effects of Blaikie Brothers, engineers and ironfounders, Footdee Ironworks, Aberdeen, and to carry on the business of engineers, ironfounders, and bridge builders, and iron, steel, and metal merchants.

QUINTON CYCLE COMPANY (LIMITED).—This Company was registered on October 27, 1891, with a capital of £35,000, in £5 shares, by Messrs. Waterlow Brothers and Layton (Limited), Birchin-lane, E.C. The objects are to acquire the business of S. and B. Gorton (Limited), cycle manufacturers, machanical and electrical engineers, &c., and to carry on the same. The first subscriber is Arthur Chamberlain, Esq., J.P., Moor Green Hall, near Birmingham.

STANDARD LAND, BUILDING, AND INVESTMENT COMPANY (LIMITED).—This Company has been formed to deal in land of all kinds, to explore, clear, fence, develop, and turn to account lands acquired by the Company, and to establish and manage public buildings of all kinds, to erect, maintain, and control *(inter alia)* water and gas works, electric light, heat, and power works, telephonic and telegraphic communication, &c. Registered on October 24, 1891, with a capital of £5,000, in £5 shares, by W. R. King, of 25, George-street, Stoke-upon-Trent.

ELECTRIC WELDING COMPANY (LIMITED).—The offices of the above-named Company have been removed from 2, Tokenhouse-buildings, London, E.C., to 6, Great George-street, Westminster, S.W. (Filed on October 26, 1891.)

LAWS' ELECTRICAL APPLIANCES COMPANY (LIMITED).—The first registered office of the above-named Company is situate at 2, Jackson-road, Holloway, London, N. (Filed on October 27, 1891.)

RAILWAY ELECTRICAL CONTRACTORS (LIMITED).—The following notice was filed on October 27, 1891:—"To the Registrar of Joint Stock Companies. I have to inform you that a meeting of the Railway Electrical Contractors (Limited) was duly held on October 23, 1891, pursuant to Section 142 of the Companies' Act, 1862, for the purpose of having an account laid before them, showing the manner in which the winding-up of the Company had been conducted, and that the same was done accordingly. Signature, Frank E. Hersee, liquidator." This Company was registered on March 12, 1884, to develope inventions for the lighting of railways, trains, and carriages by electricity. Its capital was £25,000, in £5 shares, and the first Directors were Sir Daniel Cooper, Bart., James Pender, Esq., and T. M. Collet, Esq. On the date of the last return all the shares had been taken up, of which 4,500 had been issued as fully paid. At extraordinary general meetings, held on July 13, 1889, and July 29, 1889, it was resolved that the Company be wound up, and the Company's business be sold to the Electrical Construction Corporation (Limited); and Mr. F. E. Hersee, of 144, Leadenhall-street, E.C., was appointed liquidator at a remuneration of £500, which included any other claim upon the Company's property.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts of this Company for the week ended November 1st amounted to £802; aggregate receipts for half-year to date, £12,763.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of October were £3,200, as compared with £3,310 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of October were £2,436, as compared with £2,779 in the corresponding period of last year, a decrease of £343.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of October, 1891, amounted to £60,784, against £59,589 in the corresponding period of 1890, being an increase of £1,195.

EASTERN EXTENSION TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for October amounted to £42,246, as against £47,117 in the corresponding period of last year, showing a decrease of £4,871.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—In a previous issue we gave a *résumé* of the views held by Mr. W. W. Duncan on the position of this Company's stock, and we give below an extract from his November circular:—"A great deal of good investment business has been done in these shares since I drew attention to the Company in my last report, and I am glad to say that in that short time the Company has acquired at least 250 new shareholders. This, I need hardly say, greatly strengthens the Corporation as well as the market for the shares, as they have taken the place of certain large shareholders who were obliged to sell. The more I look into the prospects of the Company the more I am satisfied it has a most brilliant future before it, and that the shares are ridiculously cheap at anything under the par price. Great steps are about to be taken in the electric lighting of our metropolis, as well as in many of our provincial towns, and this Corporation is bound to get its full share of these profitable contracts either directly or indirectly. I mean by that, supposing it does not get the direct contract for carrying out the work, as it possesses the most complete manufactory for electrical appliances, the contractors are bound to come to it for supplies. Meantime the works are all fully employed, as they have been during the past year, and the report, which will be issued shortly, will give every satisfaction. The present price of the shares includes the dividend for the whole year."

ELECTRIC TRUST (LIMITED).—The prospectus of this Trust was issued early in the current week, and the list of applications for shares closes this day (Friday). The Trust is formed with a capital of £60,200, divided into 6,000 ordinary shares of £10 each and 200 founders' shares of £1 each. Of this capital £20,200 has been privately subscribed, and the remaining 4,000 ordinary shares of £10 each were offered for subscription at par. No Directors' fees are to be paid except out of the profits, and these are limited to £50 per annum for each Director. The Directors are

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Messrs. Spencer Chadwick, H. S. King. W. R. Renshaw, and Admiral Sir G. Elliot, K.C.B. The consulting engineer is Dr. J. Hopkinson, F.R.S., and the secretary is Mr. Edward Mann, Palace-chambers, Westminster. The prospectus states that the Company was originally established in June, 1889. and consisted of eight members, who subscribed a sum of £2,000 each for the purpose of testing various methods of distributing electrical energy ; and from the experience gained by the old Company, the Directors state that they are satisfied that electricity can be generated and distributed at a cost which will leave an ample margin for profit, where the installations are properly designed and carried out with careful regard to economy and capital. Particulars follow of the working installation on the high-tension alternating system, and also the low-tension system on the installation at Palace-chambers, Westminster, which the old Company established. The objects as disclosed by the prospectus are to assist in the promotion of electric lighting power and traction.

EXETER ELECTRIC LIGHTING COMPANY (LIMITED).—This Company having obtained a Provisional Order for the supply of electricity in Exeter, are issuing £10.000 first mortgage debentures in order to defray the cost of laying mains underground.

GREAT NORTHERN TELEGRAPH COMPANY (LIMITED).—The traffic returns of this Company in October, 1891, were £24.400; January 1st to October 31st, £237.800 ; corresponding period, 1890, £232,800 ; corresponding period, 1889, £229,200.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).— The general meeting of shareholders of this Company will take place at Winchester House, Old Broad-street, E.C., on Tuesday, November 17th. The transfer books of the Company are closed from Wednesday, the 4th to Tuesday, the 17th inst., both days inclusive.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 28.		Price Wednesday, Nov. 4.		Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending Nov. 4	
										Highest.	Lowest.
			TELEGRAPHS.					£ s. d.			
£1,300,980	Stock	12/6	Anglo-American	48	49	49	50	5 4 9	Jan., Apr., July, Oct.	49⅜	48½
£2,849,510	Stock	25/0	Do. Preferred	87	88	87	88	5 16 6	" "	87½	87½
£2,849,510	Stock	5/0	Do. Deferred	12⅜	13½	12⅜	13½	..	" "	13	12⅞
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July ..	..	..
130,000	£10	5/0	Brazilian Submarine xd. and Bonus	11½	12	10⅜	11½	7 16 1	Mar., June, Oct., Dec.	11⅝	10⅞
£69,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	140	142	135	140	5 0 0	April and October ..	138	137
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	10⅜	10½
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½	4	3½	3½	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9½	10½	9½	10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10½	11½	10⅜	11⅛	6 6 0	Jan., Apr., July, Oct.	11	10⅞
400,000	10	2/6	Eastern	14⅛	14½	14⅛	14⅜	4 9 8	" "	14½	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15⅜	3 17 5	" "	15⅞	15⅝
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock... xd	108	111	106	109	3 13 5	May and November	108½	106½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	108½	108
250,000	10	2/6	Eastern Extension	15⅛	15⅜	15⅛	15⅜	4 11 1	Jan., Apr., July, Oct.	15⅝	15⅛
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	106	109	106	109	3 13 5	February & August	109	108
£85,800	100	5%	Do. 5 p. c.(Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July ..	104	..
£185,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb..1900	102	105	102	105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99	102	99	102	3 18 5	January and August	..	..
180,227	10	2/0	Globe Telegraph and Trust	9⅜	10	9⅜	10	5 7 6	Jan., Apr., July, Oct.	10	9⅜
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15	14⅜	15	4 0 0	" "	15	14⅜
150,000	10	5/0	Great Northern	18⅜	19½	18⅜	19½	4 8 4	Jan., April, and July	18⅛	18⅜
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European xd	42	44	41	43	5 16 3	May and November	..	..
88,348	10	5/0	London Platino-Brazilian	6½	7½	6½	7½	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	8	8½	7⅞	8⅛	4 16 11	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6% ..... April coupon, £2	118	123	118	123	4 17 7	" "	120	..
15,609	10	6/0	West African Telegraph	7½	8½	7½	8½	5 17 8	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	98	101	98	101	4 19 0	March & September	..	..
80,000	10	2/0	West Coast of America	3½	4	2½	3½	..	January and July ..	3	..
£150,000	100	8%	Do. Debentures 8% 1902	98	103	98	103	7 15 4	June and December	..	..
88,321	10	9d.	West India and Panama	1⅜	2	1⅛	1⅜	..	May and November	1 1/16	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	8⅜	9½	8⅜	9½	6 9 9	" "	9 5/16	9
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7⅜	8½	7⅜	8½	7 1 2	" "	..	..
61,663	15	9/0	Western and Brazilian	10⅜	11½	10½	10⅜	7 9 3	" "	11⅛	10⅞
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½	7	6⅜	7	5 7 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4½	4⅝	4	4⅛	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	104	107	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage ..... xd	120	125	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
224,850	[14/0	4·894d.	Consolidated Telephone Const. & Maintenance xd	1/16	1/16	1/16	1/16	..	May and November	⅛	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16	1/16	1/16	1/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅛	4⅜	4⅛	4⅜	6 9 9	June and December	4⅜	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13	12½	13	4 12 4	" "	12⅞	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12	13	12	13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	106	108	106	108	4 3 4	.. ..	107¼	106⅞
58,000	5	1/0	United River Plate	1	2	1	2	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	96	85	95	5 5 8	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 Sh.)	prm ⅛	⅜	4⅛	4⅜	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
5,322	£5	..	House to House Electric	..	..	4½	5	..	..	..	..
30,000	£5	3½ '90	Liverpool Electric Supply (£3 paid)	..	..	2⅜	2½	..	March and February	..	..
10,000	5	3½ '90	Do. (£5 paid)	4⅜	5⅛	4⅜	5⅛	..	" "	..	..
111,000	£5		London Electric Supply	1⅜	2⅛	1⅜	2⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9⅞	10⅛	10	10⅛	..	..	10½	10
6,318	10	..	Notting Hill Electric Lighting (£8 paid)	5½	6½	6	7	..	..	..	..
7,730	£5	3/6	St. James' and Pall Mall	8	8½	8⅛	8⅜	..	..	8⅛	8⅛
..	..	7%	Do. 7% Preference	7½	7⅞	7⅛	7⅜	..	..	7 1/16	7⅛
42,853	5	..	Westminster Electric Supply (£5 paid)	5⅝	6⅛	6	6¼	..	..	6⅛	6
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
£2,850	10	..	Blackpool Electric Tramway	..	..	..	..	..	..	..	..
77,978	3	1/8	Brush Electrical Engineering	3⅛	3⅜	3⅜	3⅝	4 19 9	..	3⅜	3⅛
69,996	2	6%	Do. 6 per Cent. Preference	2	2⅛	2⅛	2⅜	5 2 8	..	2⅜	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5	5½	5	5½	6 7 3	January and July ..	..	..
17,139	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	6%	Electric Construction	6⅜	7⅛	6⅜	7	..	—	7	6⅝
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅜	3⅝	3⅛	3⅜	..	—	3 5/16	3⅛
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20	21	20	21	4 15 3	February & August	20⅛	20⅛
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	6	7	6	7	..	January and July..	..	..
11,334	£10	8/0	Do. Preference	8⅜	9⅛	8⅛	9⅛	8 13 0	December and June	..	..
£20,000	9	1/6	Manchester Edison-Swan "A" (£1 paid)	⅛	⅜	⅛	⅜	..	..	..	..
78,849	5	2/1½	Swan United (£3. 10s. paid)	5	5½	4⅞	5⅛	6 13 4	May and November	5⅛	4⅞
87,350	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July.....	43½	42½
50,000	100	5%	Do. 5 per Cent. Bonds, red 1894	102	105	102	105	4 15 3	January and July ..	104	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid)	..	..	2⅛	2⅜	..	..	..	..
—	£5	..	Do. Preference (fully paid)	..	..	3⅜	4	..	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	3	4	—	—	—	—	—	..

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THE ELECTRICIAN:

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NOTES.

Cable makers, and ingenious electricians generally, will do well to take note of the correspondence on "Coast Communication" published in *The Times* of Tuesday last, and of its leader thereon the same morning. When the leading journal takes up a subject of this kind in earnest, we may safely conclude that public opinion has been sufficiently and definitely formed, and that the time for action has arrived. *The Times* repeats only what has been said over and over again for many years past; but the publicity of its advocacy will work greater marvels than all the letters that have ever been written; and its concluding words, "Is England content to let her sailors perish by hundreds for want of a little money or for want of a little care?" will probably awaken a response which no other power could have extorted. But something else remains to be done. Certain links in the chain of a complete system of coast communication involve engineering and electrical problems which have still to be solved; and it is to be hoped, when the time arrives for practical experiments to be renewed, that these difficulties may be more successfully overcome than has yet been the case.

Mr. Heaviside's article in our present issue is devoted to a somewhat abstruse but highly important subject—the use of vectors in analysis. The writer discusses in his usual lively and combative manner the great advantages of vector methods over the ordinary Cartesian or quaternion processes; and points out that these advantages are specially important in connection with physical questions. Comparatively few are familiar with the habits of vectors, mainly owing to the absence of an elementary text-book treating of their properties; and we feel sure that a compact summary of the chief facts about them, together with a demonstration of the ease with which they can be used, will prove of great value. Electrical engineers are constantly dealing with vector quantities, although they may not be aware of the fact.

No conception has proved of more use to electricians than that of lines of force; yet no idea could initially be more abstruse or more purely mathematical. The two properties of a vector, those of magnitude and direction, are exactly typified in lines of force. Here the magnitude corresponds with the strength of the magnetic field, and the direction involved is that of the line of force. But vectors are so little understood that the two properties are generally divided; direction is assumed alone, and the strength of the field is described as containing a certain number of lines of force. By way of improving this, the idea of tubes of force has been suggested; but having been used chiefly by writers of a mathematical bent, it has needlessly alarmed many students. Nor is the idea of direction always allowed to remain in its simplicity; frequently in speaking of the magnetism due to the earth we talk of the horizontal and vertical components. But the division of the field into two parts like this is very artificial and really introduces complication. The resultant magnetic field is the only one which has a real existence; and, if we are considering the matter from a mathematical standpoint, it is to this resultant field that our symbols should refer. It is thus the vector quantity which we should deal with, and not the Cartesian components. For reasons of this kind Mr. Heaviside objects to the use of Cartesian methods, and condemns the use of quaternions on account of their complication. The use of vector analysis appears hard merely because it is unfamiliar.

We print to-day a singularly modest letter from Mr. Whitmell, a gentleman distinguished in a widely different branch of natural science, describing how in 1863 he was in correspondence with Faraday on the subject of the possibility of making a magneto-electric machine excite its own magnets. The letter is interesting not only as affording one more proof that this subject was at that date distinctly "in the air," but as revealing on the one hand a curious ignorance of the prior suggestions of Jacob Brett and of Hjorth, and on the other a curious scepticism as to the practicability of the oft-suggested device. A further point of interest is the supposed necessity of beginning with a battery current—a device also re-suggested in 1867 by more than one of the tribe who rushed to the Patent Office to substantiate their claims to the principle of auto-excitation.

The dispute between the local gas concern and the municipal authorities of Sedan, to which a brief reference is made in our Notes columns this week, is an instance of the difficulties in which our Continental friends are not unfrequently landed by their *penchant* for granting monopolistic concessions. With us the Electric Lighting Act of 1888 expressly states that the granting of a Provisional Order in no way confers a monopoly; nevertheless, it is tacitly understood that so long as "under-

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takers" carry out their obligations in a proper manner they will not be hampered by undue competition. An honourable understanding of this kind is worth reams of parchment. In the case of Sedan gas was given the monopoly until well into the 20th century, a saving clause being introduced to the effect that the agreement might be incontinently cancelled by the Municipality if the progress of science resulted in any improved mode of lighting, and if that improvement were generally adopted for at least two years in towns of a similar size. About two years ago the local authorities came to the conclusion that the conditions mentioned in the saving clause had arisen by reason of the development of electric lighting, and forthwith granted yet another concession—this time to electricity—with the result that they have been condemned to pay compensation, with legal costs, to the Gas Company. Under the circumstances there is little reason to sympathise with the Municipality of this historic town.

The engines and dynamos at the Cologne Municipal station, which is fully described in our columns this week, are of a type which has become firmly established in Germany. Horizontal engines coupled direct to dynamos have been used for ship-lighting by English makers, but we have no example of such an arrangement in a supply station. An exceptionally slow speed appears to be generally adopted on the Continent; and Sulzer engines, which were represented by a very good specimen at the Paris Electrical Exhibition of 1881, are as popular on the Continent as Willans engines are with us. But price seems to be no object at all in Germany. Not only is an extremely expensive mode of building very common, but these slow speeds necessitate proportionately large dynamos.

The use of an exciter mounted on the same shaft as the alternator has been adopted by Mr. Ferranti and Mr. Mordey in certain cases; but the extra cost of this arrangement at the Cologne station must be very considerable, the weight of the armature of the exciter for the 600 unit being 22 cwt., *i.e.*, about the weight of a 50 H.P. armature as made in England. The interlocking switch arrangements appear to be excellent, and are evidently the design of an electrical engineer and not of an electrician. There is still rather too much crockery and lacquered brass about our English stations, and switchboard making is largely in the hands of instrument makers. The fierce cutting of contracts has much to do with the flimsy and ill-designed work that has been put into some of our engine-rooms. Practically the whole switchboard of one of the London stations was pulled out after the engineer had tried hard to make it do what the contractors intended; and at another it was intended to use an entire set of rather complicated switches for a purpose totally different to that for which the contractors had designed them.

One of the most important matters which Major Marindin had to consider in the course of the Board of Trade inquiry in 1889 was the question of competition between supply companies in the same district. Various arguments were used, and the general idea seemed to be that, on the principle of "the more the merrier," when two companies had the run of one district each would race for the largest number of customers. There exists, however, at the present moment a district within a district which is "served" by no less than three companies, where the pleasing supposition has not been verified by the actual facts. Onslow-square is in this privileged region, and although the House-to-House Company have found it worth while to push their wires through a decidedly less favourable district up to the western limit of the square, no electric supply whatever is to be had by the unfortunate householders, who have wired their houses on the strength of the assurances of canvassers from the Chelsea side.

The Chelsea Company, unlike other supply companies, cannot extend its operations by merely putting down mains in the streets, but is obliged to build battery stations at intervals, and the would-be customers in the Onslow-square neighbourhood are told that there have been great difficulties in getting a site. But the London Electric Supply Company have also a right to supply this district, and for some mysterious reason have agreed to abstain from supplying anybody but their own Directors. The Cadogan Company, which is chiefly remarkable for being the only one in London in which the dynamos are driven in the old-fashioned way by leather belts, supplied only 25 houses during 1890; and at the end of February could only boast of 16 customers in Chelsea, owing to a re-arrangement of districts. The London Company would be glad to have a few more customers when they have surmounted the little difficulties which have been recently inconveniencing them at Deptford; and these, so far as we have heard, might have been more easily remedied if the Company had not declined to avail themselves of the further services of their late engineer.

The one thing that the engineer of a well-arranged supply station yearns for is a good load-factor. He has but little complaint to make about his steam engines, his dynamos are as near perfection as possible, his losses in distributing need not be serious, and he is becoming aware that even his coal bill is a minor matter. What he wants is to give his plant a good long run when it is once started. If a good load-factor is to be found anywhere it should be that of the Hammerfest station, described by our Scandinavian correspondent in another column. A night of 66 days, on the other hand, must tax the smooth running of the bearings, though the staff have plenty of time to contemplate improvements during the period of 71 days when no light is required.

Erratum.—On p. 7 of our last issue read "in *Düsseldorf* the total length of gas main is about 116 kilometres," instead of "in Darmstadt," &c.

Mutual Telephone Company.—There are now 750 subscribers to this Company's Manchester exchange. The Company has, in addition, 38 private wires completed.

Junior Engineering Society.—We are informed that Sir E. J. Reed has been elected President of the Junior Engineering

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Society, and will deliver his presidential address on the 27th inst.

Paddington.—The Vestry has been informed by the Metropolitan Electric Light Company that it intends to supply all buildings in Paddington with electrical energy at 7d. per Board of Trade unit.

Personal.—Mr. George North has resigned his position as General Manager to Woodhouse and Rawson United, and intends to commence business on the 16th inst. at 90, Queen-street, E.C.

New Book.—We are informed by Messrs. Whittaker and Co. that Mr. Stuart A. Russell's new work on electric light cables and the distribution of electricity will be issued shortly in the "Specialists' Series."

Brighton.—At the last meeting of the Town Council the Lighting Committee reported that on the 26th ult. they had resolved that Mr. Arthur Wright be appointed manager of the Corporation Electricity Undertaking, at a salary of £300 per annum.

Telephonic Communication between Lincoln and Liverpool.—Telephonic communication was established between Lincoln and Liverpool on Thursday last week, when the Mayors of both cities spoke through to each other, and offered congratulations on the success of the enterprise.

Fire at Messrs. Clarke, Chapman, and Co.'s Works.—On Tuesday night a fire occurred at the works of this firm, Park-lane, Gateshead, which resulted in serious damage; the flames also damaged the roof the Sunbeam Lamp Company's works, but the whole of the lamp stock was rescued.

Telegraphic Communication with Mashonaland.—A Reuter telegram from Fort Victoria, Mashonaland, says:—"The extension of the British South African Company's telegraph line from Mafeking and Cape Town to Fort Victoria has now been completed, and an office has been opened at this place."

Aluminium.—Reports from Pittsburg announce that the German military authorities have ordered from a firm in that town immense quantities of waterbottles and cartridge cases made of aluminium. The object is to lighten, as far as possible the weight of the soldiers' accoutrements. No less than 500 tons will be required to execute the orders already received.

Worcester.—At the last meeting of the Watch Committee the subject of electric lighting was again discussed. On the recommendation of the sub-committee, it was resolved to recommend the City Council to authorise the committee to publish advertisements inviting tenders for the construction of electric lighting works, enabling the Council to supply electricity equivalent to 12,000 10 c.p. lamps.

Finchley.—An exhaustive report has been submitted to the Finchley Local Board upon the lighting of their district by electricity by their engineer and surveyor, in which he recommends the adoption of the transformer system. The cost of the installation he estimates at £17,000. At a meeting of the Board, held on 27th ult., it was resolved that an application be made to the Board of Trade for a Provisional Order.

Cutting Telegraph Wires.—At the Mansion House on Wednesday Edward Green was sentenced to one month's imprisonment, in default of £5 fine and £4 damages, for cutting the Exchange Telegraph Company and the Boy Messengers and Electric Call Company's wires in St. Paul's Churchyard. The wires being of a substantial character occupied the accused, who was equipped with a large knife, from 10:30 till midnight.

Royal Scottish Society of Arts.—Prizes and medals have just been awarded by this Society on account of Papers read at the meetings during the session of 1890-91—in all about fifteen. The most valuable award is the Keith prize of £21, given to Dr. R. Milne Murray for his paper "On an Electrical Bench for Physiological Research." Professor A. B. W. Kennedy, Professor T. H. Beare, and Mr. A. R. Bennett are amongst the recipients of awards.

Electric Railways for Berlin.—As a set-off to the Siemens project of elevated electric tramways for Berlin, the Allgemeine Elektricitäts-Gesellschaft has petitioned for a concession for the construction of underground electric railways. The last-named scheme embraces three different lines of railway. The tunnels would consist of large iron tubes, screwed and cemented together. Trains are to be run in each direction at intervals of three minutes. Each train would consist of an engine and three carriages, with accommodation for passengers 120 in all. A speed of 16 miles an hour is to be attained.

Joule's Law.—An experimental demonstration of Joule's law has been furnished by Prof. Robert Spice, of Brooklyn. The method employed is to send a current through a known resistance, immersed in a known quantity of liquid, and also to immerse in the same liquid one set of junctions of a small thermo battery connected with a galvanometer. The other set of junctions are immersed in another vessel in a known volume of the same liquid, in which is another known resistance. If both quantities of liquid are heated by the current to the same temperature the galvanometer will remain at zero, but not otherwise. The results of the experiments show that the rise of temperature of the liquids is proportional to the electrical energy expended.

A Use for Old Incandescent Lamps.—In the *Bulletin de l'Association Belge de Photographie* for July, Prof. F. Leconte has a brief note describing some experiments made by him for the purpose of testing the suitability of the incandescent lamp as an indicator of vibrations. A Khotinsky lamp with a looped filament was placed on one of the supports of the Physical Laboratories of the Ghent Institut des Sciences, and a telescope was fixed on another of the supports, the lamp being lit up from behind. Blows on the floor, which did not affect the mercury troughs usually employed for the purpose in the slightest degree, threw the filament into a state of vibration lasting several seconds. Prof. Leconte points out that a long looped ruptured filament is the best, and that the vacuum must be good and the bulb unblackened.

Leeds Electric Tramway.—The Wigan tramways, which have been worked by steam power, have recently been sold to a syndicate. These lines have not proved a success, and the syndicate consulted Mr. John Waugh, of Bradford, who advised the adoption of electricity as the motive power. On Saturday last Mr. Gee (chairman of the syndicate) brought over several representatives of the Wigan Corporation and of the Hindley, Ince, and Pemberton Local Boards to inspect the Roundhay line. They were met by Mr. Graff Baker, the lessee of the line, had a run on the cars, and visited the power station.—On Tuesday the line was officially inspected by Major-General Hutchinson and Major Cardew. At different points on the route experiments were made with the object of testing the capabilities of the cars in regard to speed, brake-power, and other qualities, and in every instance the results appeared to be quite satisfactory.

Lord Mayor's Show.—A feature in the procession on Monday was "a car emblematical of the Guilds and City of London Institute—wood-carving, turning, modelling, drawing. The car drawn by six horses." To be quite up to date there should have been two "third-year students" conducting an original research.—At the banquet in the evening the Guildhall was, for the first time, lighted by electricity. The light was chiefly given by 14 chandeliers, in two rows of seven each down the hall. Each chandelier had three tiers of lights, the uppermost consisting of 18 8-c.p. incandescent lamps, the second of nine 16-c.p. lamps, and the lowest of five 16-c.p. lamps. The diameters of the tiers decreased from the uppermost to the lowest, so that the lamps were approximately arranged to form an inverted cone. Suspended along the centre of the hall by cables running across it near the roof were three or four 500-c.p. incandescent lamps. The arrangements were carried out by the Brush Company.

Research Studentship.—The Coutts Trotter studentship, of the annual value of £250, for the promotion of original research in natural science, more especially physiology and experimental physics, open to graduates of Trinity College, Cambridge, not being Fellows, who are not of more than seven years' standing from the time of commencing residence, has been awarded to John Walton Capstick, B.A., scholar of the College. Mr. Capstick obtained a first class in the Natural Sciences Tripos,

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Part I., June, 1890, and a first class in the Natural Sciences Tripos, Part II., June, 1891, being distinguished in chemistry and physics.

Huddersfield.—Appointment Vacant.—The Corporation of Huddersfield being about to erect an electric lighting station, are prepared to receive applications from electrical engineers competent to superintend the execution of the works, the contractors for which are the Brush Electrical Engineering Company. Applications should be addressed to Mr. H. Barber, Town Clerk, Town Hall, Huddersfield, and endorsed "Electrical Engineer," and must be delivered by 25th inst. The officer appointed will be required to devote the whole of his time to the duties. No canvassing will be permitted. For further particulars see our advertisement columns.

The Crystal Palace Electrical Exhibition.—A meeting of the Honorary Council of Advice, and of the Special Committee appointed by the Electrical Section of the London Chamber of Commerce, will be held at the Mansion House at three o'clock on Wednesday, the 25th inst., when a report on the progress of the Exhibition will be presented, and the question of how the Exhibition may best be used as a means of advancing the interests of electrical science will be considered. The Lord Mayor will preside. The whole of the space is now practically allotted, extra buildings having been erected for certain large installations which could not otherwise have been accommodated.

The County Council and the Testing of Meters.—Mr. G. W. Hemming writes as follows in *The Times* of yesterday :—

Much as I may admire the high policy of the County Council, I cannot help thinking that they are a little remiss in the performance of their workaday duties. One of these is to protect the public by testing and certifying the accuracy of the meters supplied by electric supply companies. I am informed by one of these companies who ought to be supplying me with light that they have had 100 meters in the hands of the County Council for six or seven months, and cannot get them back, and that they do not know how much longer I may have to wait before they can put in a meter. As I have already lived nearly two months with my gas put out and nothing to replace it, I think I may fairly complain of the County Council for neglect of duty ; and as my case is only one of a multitude of like instances it does seem that the County Council are wantonly inflicting a grievous inconvenience upon a large number of the constituents whom they tax so freely. If you will kindly insert this letter it may perhaps induce them to moderate their policy of neglect.

Leicester.—About a fortnight ago, on the invitation of Mr. Lennard, the chairman of the Corporation Gas Committee, the members of the Town Council and a large number of other gentlemen, assembled at the Aylestone-road Gasworks to inspect them, and to receive from Mr. Lennard some information respecting electric lighting and the position of the Corporation in relation thereto. Mr. Lennard said it seemed to him that, if electric lighting could be made to pay, they ought to set about taking advantage of their Order at once. The principal question they had to determine, however, was which was the best mode of generating electricity. He was afraid they could not make the concern pay if they generated the electricity by the aid of steam ; and he should be prepared to recommend the Corporation to adopt gas-engines. At present they proposed to have stations in various parts of the town, and not distribute the power from any station over a radius of more than a quarter of a mile. Should the Corporation think it advisable to carry out the Order, a committee would formulate a plan as to where the stations should be placed, and the winter of 1892 should see a good deal of electric lighting in the town.

Islington Vestry.—Messrs. Sharp and Kent are in negotiation with the Islington Vestry with a view of obtaining its sanction to their proposed Provisional Order. Messrs. Sharp and Kent state that they have expended about £10,000 in developing the electric station at the back of Mr. Beale's premises, and they have in contemplation the immediate expenditure of another £5,000. They are supplying about 2,000 lights, besides supplying current to lifts, pumps, &c. At the meeting of the Vestry, when a letter to the above effect from Messrs. Sharp and Kent was considered, a report was received from the Works Committee stating that it had considered the letter from the Board of Trade transmitting copy of letter received from the Postmaster-General with regard to the construction of certain underground electric lighting works in the parish by persons possessing no Parliamentary powers. It was resolved that it was absolutely necessary that a Provisional Order or Licence should be obtained. A letter was also received from the City of London Electric Lighting Company, stating that they proposed to apply for a Provisional Order for the lighting of the parish with electricity, and asking the Vestry to give their sanction.

Gas v. Electricity at Sedan.—An action for breach of contract brought by the Compagnie Française d'Éclairage et de Chauffage par le Gaz, against the Municipality of Sedan, has just been decided in favour of the Gas Company, by the Conseil de Préfecture des Ardennes. An electric lighting concession was recently granted by the town to MM. Colette et Fédrick, in contravention, so the Gas Company alleged, of Article 10 of its concession, which reads as follows :—"It is expressly agreed that if by reason of the progress of science or discovery any new mode of lighting whatsoever shall have been adopted for at least two years in towns of the same importance as Sedan, before the expiration of the present agreement, the Municipality reserves to itself the right of annulling this agreement without compensation, in order to give the town the advantage of the new mode of lighting. Under these circumstances the existing Company will be called upon to enter into a fresh agreement with the town, and, other things being equal, preference will be given to its offer." The Conseil de Préfecture held that the Municipality of Sedan had violated its agreement by authorising MM. Collette et Fédrick to run overhead electric light wires, and that its contention that the clause quoted above did not apply to private lighting could not be sustained. In return for the certain privileges, the Gas Company had bound itself to supply light until January 1, 1917, and the electric lighting concession was an infraction of these privileges, the state of things alluded to in Article 10 not existing. The Municipality was condemned to pay 14,000fr. damages and costs.

The Pittsburgh Street Railway Convention.—We give in another column a sober *résumé* by our New York correspondent of the proceedings at the recent gathering of street railway men at Pittsburgh. The following extracts from the *Electrical World* will show that these proceedings were also of a "lively" character. "The tenth annual convention of the American Street Railway Association at Pittsburgh went off with *éclat*," says our contemporary. "There was a larger attendance, a larger number of exhibits, and larger numbers of places in which to hunt for them than at any previous convention. The delegates were distributed over a greater number of hotels, hunted for each other with more unrewarded pertinacity, and as a consequence did more general kicking than on any similar occasion. The clans began gathering by as early as Monday, October 19th. The large companies who had exhibits for the first comers were a busy crowd, intent on unpacking and arranging machinery, hunting accommodations and getting on the soft side of the Pittsburgh newspaper reporters—all of which feats were accomplished with distinguished success. On all sides of the hotel were displayed cars and trucks. The Thomson Houston, Westinghouse, and Short companies had special cars for the display of their latest motors, while the Edison Company attended to the big residual crowd in the hotel by making the wheels go round in its own rooms. The Westinghouse Company had its standard trucks, including the gearless and an additional magnificent 'bluff' in the shape of one of its single-reduction gear motors running under water in a great tank—not that its street railway motors are intended to run under water, but the exhibition was a fine example of good insulation. On the street car tracks the Thomson-Houston took the warpath with a beautiful long car mounted on radial trucks and equipped with two of the new W.P. motors. The Short Company followed suit with a fine gearless car that carried crowds over the road, while the Westinghouse contingent had a gearless car in regular service, resplendent with flags, and running like a scared cat every time the track was tolerably free of obstructions." After all this, it seems only in keeping to learn that the homeward journey of the delegates was marred by "a prosaic and exasperating freight wreck," and that the Lewis and Fowler cars "pulled into New York seven hours late."

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ELECTROMAGNETIC THEORY.—XIX.

BY OLIVER HEAVISIDE.

(Continued from page 709, Vol. XXVII.)

§ 97. Ordinary algebra, as is well known, treats of quantities and their relations. If, however, we examine geometry, we shall soon find that the fundamental entity concerned, namely a straight line, when regarded as an entity, cannot be treated simply as a quantity in the algebraical sense. It has, indeed, size, viz., its length; but with this is conjoined another important property, its direction. Taken as a whole, it is a Vector. In contrast with this, an ordinary quantity, having size only, is a Scalar.

Again, if we consider the mathematics of physical questions, we find two distinct kinds of magnitudes prominently present. All such magnitudes as mass, density, energy, temperature, are evidently quantities in the simple algebraical sense; that is, scalar magnitudes, or simply scalars. A certain (it may be an unstated) unit of density, for instance, being implied, any density is expressed by a simple number. (The question of the "dimensions" of physical magnitudes is not in question.) All magnitudes whatever which have no directional peculiarity and which are specified by a single number are scalars, and subject to scalar algebra.

But such magnitudes as displacement, velocity, acceleration, force, momentum, electric current, &c., which have direction as well as size, and which are fully specified by statement of the size and direction, are vector magnitudes, or simply vectors. Now, just as there is an algebra and analysis for scalars, so is there a vector algebra and analysis appropriate to vectors; and it is the object of the present chapter to give a brief account of the latter, especially in respect to its application to electromagnetism.

§ 98. Algebraical or analytical geometry in the usual Cartesian form, though dealing ultimately with vectors, is not vectorial algebra. It is, in fact, a reduction to scalar algebra by resolution of every vector into three rectangular components, which are manipulated as scalars. Similarly, in the usual treatment of physical vectors, there is an avoidance of the vectors themselves by their resolution into components. That this is a highly artificial process is obvious, but it is often convenient. More often, however, the Cartesian mathematics is ill-adapted to the work it has to do, being lengthy and cumbrous, and frequently calculated to conceal rather than to furnish and exhibit useful results and relations in a ready manner. When we work directly with vectors, we have our attention fixed upon them, and on their mutual relations; and these are usually exhibited in a neat, compact, and expressive form, whose inner meaning is evident at a glance to the practised eye. Put the same formula, however, into the Cartesian form, and—what a difference! The formula which was expressed by a few letters and symbols in a single line, readable at once, sometimes swells out and covers a whole page! A very close study of the complex array of symbols is then required to find out what it means; and, unless the notation be thoroughly symmetrical, it becomes a work of time and great patience. In this interpretation we shall, either consciously or unconsciously, be endeavouring to translate the Cartesian formula into the language of vectors.

Again, in the Cartesian method, we are led away from the physical relations that it is so desirable to bear in mind, to the working out of mathematical exercises upon the components. It becomes, or tends to become, blind mathematics. It was once told as a good joke upon a mathematician that the poor man went mad and mistook his symbols for realities; as M for the moon and S for the sun. There is another side to the story, however. If our object be ultimately physical, rather than mathematical, then the more closely we can identify the symbols with their physical representatives the more usefully can we work, with avoidance of useless—though equally true—mathematical exercises. The mere sight of the arrangement of symbols should call up an immediate picture of the physics symbolised, so that our formulæ may become *alive*, as it were. Now this is possible, and indeed, comparatively easy, in vectorial analysis; but is very difficult in Cartesian analysis, beyond a certain point, owing to the geometrically progressive complexity of the expressions to be interpreted and manipulated. Vectorial algebra is the natural language of vectors, and no one who has ever learnt it (not too late in life, however) will ever care to go back from the vitality of vectors to the bulky inanimateness of the Cartesian system.

§ 99. But supposing, as is generally supposed, vector algebra is something "awfully difficult," involving metaphysical considerations of an abstruse nature, only to be thoroughly understood by consummately profound metaphysico-mathematicians, such as Prof. Tait, for example. Well, if so, there would not be the slightest chance for vector algebra and analysis to ever become generally useful; and I should not be writing this, nor should I have, for several years past, persisted in using vector algebra in electromagnetic theory—a prophet howling in the wilderness. It will readily be concluded, then, that I believe that the vector analysis is going to become generally used in scientific work, and that what is needed is not "awfully difficult." There was a time, indeed, when I, although recognising the appropriateness of vector analysis in electromagnetic theory (and in mathematical physics generally), did think it was harder to understand and to work than the Cartesian analysis. But that was before I had thrown off the quaternionic old-man-of-the-sea who fastened himself on my shoulders when reading the only accessible treatise on the subject—Prof. Tait's Quaternions. But I came later to see that, so far as the vector analysis I required was concerned, the quaternion was not only not required, but was a positive evil of no inconsiderable magnitude; and that by its avoidance the establishment of vector analysis was made quite simple and its working also simplified, and that it could be conveniently harmonised with ordinary Cartesian work. There is not a ghost of a quaternion in any of my papers (except in one, for a special purpose). The vector analysis I use may be described either as a convenient and systematic abbreviation of Cartesian analysis; or else, as Quaternions without the quaternions, and with a simplified notation harmonising with Cartesians. In this form, it is not more difficult, but easier to work than Cartesians. Of course you must learn how to work it. Initially, unfamiliarity may make it difficult. But no amount of familiarity will make Quaternions an easy subject.

Maxwell, in his great treatise on Electricity and Magnetism, whilst pointing out the suitability of vectorial methods to the treatment of his subject, did not go any further than to freely make use of the idea of a vector, in the first place, and to occasionally express his results in vectorial form. In this way his readers became familiarised with the idea of a vector, and also with the appearance of certain formulæ when exhibited in the quaternionic notation. They did not, however, derive any information how to work vectors. On the whole, I am inclined to think that the omission of this information has not tended to impede the diffusion of a knowledge of vector analysis. For, had he given an account of the theory, he would certainly have followed the Hamilton-Tait system; and this would probably, for reasons I shall shortly mention, have violently prejudiced his readers against the whole thing.

But the diffusion of vector analysis has, undoubtedly, in my opinion, been impeded by the absence of sufficiently elementary works on the subject, with a method of establishment of principles adapted to ordinary minds, and with a conveniently workable notation. For the reader of Maxwell's treatise who desired to learn to work vectors in analysis had either to go to Hamilton's ponderous volumes, or else to Prof. Tait's treatise. The former are out of the question for initiatory purposes. But the latter is excessively difficult, although described as "an elementary treatise"—not the same thing as "a treatise on the elements." The difficulty arises in a great measure from the quaternionic basis.

§ 100. Suppose a sufficiently competent mathematician desired to find out from the Cartesian mathematics what vector algebra was like, and its laws. He could do so by careful inspection and comparison of the Cartesian formulæ. He would find certain combinations of symbols and quantities occurring again and again, usually in systems of threes. He might

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introduce tentatively an abbreviated notation for these combinations. After a little practice he would perceive the laws according to which these combinations arose and how they operated. Finally, he would come to a very compact system in which vectors themselves and certain simple functions of vectors appeared, and would be delighted to find that the rules for the multiplication and general manipulation of these vectors were, considering the complexity of the Cartesian mathematics out of which he had discovered them, of an almost incredible simplicity. But there would be no sign of a quaternion in his results, for one thing; and, for another, there would be no metaphysics or abstruse reasoning required to establish the rules of manipulation of his vectors. Vector analysis is, in its elements, entirely independent of the exceedingly difficult theory of Quaternions; that is, when the latter is treated quaternionically *ab initio*.

"Quaternion" was, I think, defined by an American schoolgirl to be "an ancient religious ceremony." This was, however, a complete mistake. The ancients—unlike Prof. Tait—knew not, and did not worship Quaternions. The quaternion and its laws were discovered by that extraordinary genius Sir W. Hamilton. A quaternion is neither a scalar, nor a vector, but a sort of combination of both. It has no physical representatives, but is a highly abstract mathematical concept. It is the "operator" which turns one vector into another. It has a stretching faculty first, to make the one vector become as long as the other; and a rotating faculty, to bring the one into parallelism with the other.

Now in Quaternions the quaternion is the master, and lays down the law to the vector and scalar. Everything revolves round the quaternion. The laws of vector algebra themselves are established through Quaternions, assisted by the imaginary $\sqrt{-1}$. But I am not sure that any one has ever quite understood this establishment. It is done in the second chapter of Tait's treatise. I never understood it, but had to pass on. That the establishment is not demonstrative may be the reason of the important changes made therein in the third edition. But it is still undemonstrative to me, though much improved. Now this relates to the very elements of the subject, viz., the scalar and vector products of a pair of vectors, the laws of which are quite plain in the Cartesian mathematics. Clearly, then, the quaternionic is an undesirable way of beginning the subject, and impedes the diffusion of vectorial analysis in a way which is as vexatious and brain-wasting as it is unnecessary.

§ 101. Considering the obligations I am personally under to Prof. Tait (in spite of that lamentable second chapter), it does seem ungrateful that I should complain. But I have at heart the spread of a working knowledge of elementary vector analysis quite as much as Prof. Tait has the extension of the theory of Quaternions. Besides, Prof. Tait has assumed a very conservative attitude in relation to Hamilton's grand system. For instance, to "more than one correspondent" who had written for explanation of something they found obscure—and the same thing occurred to me—described in his treatise by "It is evident, . . .", he, "on full consideration," decides not to modify it, but to italicise the words! He also told them that if they did not see it, in the light of certain preceding parts of the treatise, then they had "begun the study of Quaternions too soon" (Third edition, p. 110). This is as characteristic of the sardonic philosopher as a certain heavy kind of "flippancy" is of the Cockney. Again, in his Preface he states one cause of the little progress made in the development of Quaternions to be that workers have (especially in France) been more intent on modifying the notation or the mode of presentation of the elementary principles, than in extending the application of the calculus. "Even Prof. Willard Gibbs must be ranked as one of the retarders of quaternionic progress, in virtue of his pamphlet on Vector Analysis, a sort of hermaphrodite monster, compounded of the notations of Hamilton and Grassmann." Grassmann, I may observe, established, *inter alia*, a calculus of vectors, but not of quaternions.

Prof. W. Gibbs is well able to take care of himself. I may, however, remark that the modifications referred to are evidence of modifications being felt to be needed; and that Prof. Gibbs' pamphlet (Not Published, Newhaven, 1881-4, pp. 83), is not a quaternionic treatise, but an able and in some respects original little treatise on vector analysis, though too condensed and also too advanced for learners' use; and that Prof. Gibbs, being no doubt a little touched by Prof. Tait's condemnation, has recently (in the pages of *Nature*) made a powerful defence of his position. He has by a long way the best of the argument, unless Prof. Tait's rejoinder has still to appear. Prof. Gibbs clearly separates the quaternionic question from the question of a suitable notation, and argues strongly against the quaternionic establishment of vector analysis. I am able (and am happy) to express a general concurrence of opinion with him about the quaternion, and its comparative uselessness in practical vector analysis. As regards his notation, however, I do not like it. Mine is Tait's, but simplified, and made to harmonise with Cartesians.

§ 102. In Quaternions, the square of a unit vector is -1. This singular convention is quaternionically convenient. But in the practical vector analysis of physics it is particularly inconvenient, being indeed, an obtrusive stumbling-block. All positive scalar products have the *minus* sign prefixed; there is thus a want of harmony with scalar investigations, and a difficulty in readily passing from Cartesians to vector and conversely. My notation, on the other hand, is expressly arranged to facilitate this mutual conversion.

As regards the establishment of the elementary vector algebra, that is quite simple (freed from the quaternion); it all follows from the definitions of a vector and of the vector and vector products of a pair of vectors.

Now I can imagine a quaternionist (unless prejudiced) admitting the simplicity of establishment and of operation, and the convenience of the notation, and its sufficiency for practical requirements up to a certain point; and yet adding the inquiry whether there is not, over and above this vector analysis, a theory of Quaternions which is overlooked. To this I would reply, Certainly, but it is not food for the average mathematician, and can, therefore, never be generally used by him, his practical requirements being more suitably satisfied by the rudimentary vector analysis divested of the mysterious quaternion. This does not exclude the important theory of Δ and its applications. Prof. Gibbs would, I think, go further, and maintain that the anti- or ex-quaternionic vectorial analysis was far superior to the quaternionic, which is uniquely adapted to three dimensions, whilst the other admits of appropriate extension to more generalised cases. I, however, find it sufficient to take my stand upon the superior simplicity and practical utility of the ex-quaternionic system.

We may, however, if we wish to go further, after ex-quaternionic establishment of vector algebra, conjoin the scalar and vector, and make the quaternion, and so deduce the whole body of Quaternions. But sufficient for the day is the labour thereof; and we shall now be concerned with scalars and vectors only. The reader should entirely divest his mind of any idea that we are concerned with the imaginary $\sqrt{-1}$ in vector analysis. Also, he should remember that unfamiliarity with notation and processes may give an appearance of difficulty that is entirely fictitious, even to an intrinsically easy matter; so that it is necessary to thoroughly master the notation and ideas involved. The best plan is to sit down and work; all that books can do is to show the way.

Errata.—I should be obliged if those who honour me by reading my articles would make these corrections on p. 709, Art. XVIII.:—

In equation (14) transpose S and S_i.

In equation (25) delete $= L_i/L = M_i/M$, and add a new equation, namely, $x^2 = L_i/L = M_i/M$.

In equation (33) for ρ read ρ/c.

I may add that the quickest way of comparing irrational with rational quantities is by equating corresponding expressions for the energy in given cases, rather than by going to central forces, which is principally useful from its following the ordinary method.

(To be continued.)

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A PLAN OF CONNECTIONS FOR EFFECTING SEVERAL TESTS WITH ONE GALVANOMETER.

BY E. H. DRAPER.

By means of the plan of connections sketched in the accompanying diagram, *seven* different tests, most useful on ship or in shore testing-rooms, may all be taken with the same galvanometer. These tests are as follows:—

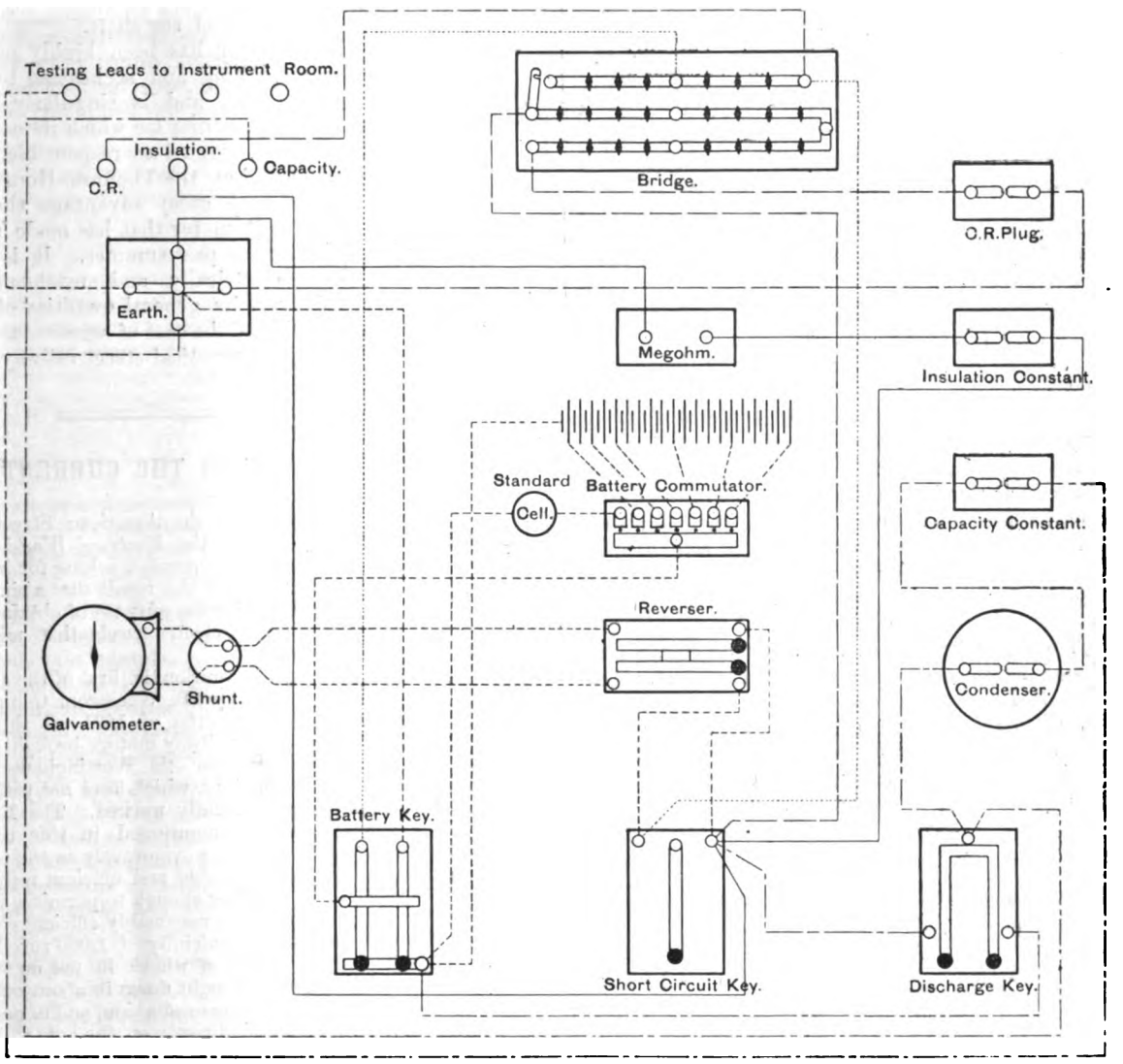

DIAGRAM OF CONNECTIONS.

Connections common to all
C. R.
Capacity
Insulation
C. R. and Insulation

(1.) C. R. = Join up the C. R. Plug and the arm of the Bridge, which otherwise leave open.
(2.) Insulation = as per sketch.
(3.) Insulation Constant = Plug in Insulation Constant Plug.
(4.) Capacity = as per sketch.
(5.) Capacity Constant = Plug in Capacity Constant Plug.
(6.) Battery Resistance = Same as No. 3.
(7.) Electromotive Force of Batteries = By comparison, through Condenser, with Standard Cell. Same as No. 5.

This plan of connection requires little or no changing of plugs or connections, and is therefore more reliable. As seen in the sketch, there are three terminals marked "C. R.," "INSULATION," and "CAPACITY," which are joined for either test, to one of the testing leads. For insulation and capacity no changes are required, simply testing as usual with short circuit key for insulation and discharge key for condenser. For the tests for insulation and capacity constants, simply join up plug commutator in either case, as shown in sketch. For battery resistance, take by half deflection method, using insulation constant. For electromotive force of a battery use capacity constant, and compare with standard cell, in connection with battery commutator. In all foregoing tests be careful that the arm of bridge cuts off connection, as shown in sketch. For C. R. join up the arm of the bridge and plug in bridge commutator, being careful that all other plugs are out; also join testing lead to C. R. terminal.

THE THOMSON-HOUSTON W.P. RAILWAY MOTOR.*

One of the most interesting exhibits at the Pittsburg Street Railway Convention was a new slow speed railway motor of the Thomson-Houston Company, of which the accompanying illustrations give an excellent idea. It has been in process of evolution for six months or more, and has been worked up under the careful superintendence of Mr. Walter Knight.

* From *The Electrical World*.

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The new machine embodies some decidedly novel features, and its excellent performance on the special car equipped with it was very favourably commented upon. It is known to the trade as the W.P. motor, which being interpreted means water proof, and it well deserves the name, because of the particularly complete ironclad character of the field magnets.

Fig. 1 gives a perspective view of the motor, and from it the arrangement of the iron is at once obvious. Singularly enough, it is a two-pole machine, so arranged on the theory that the comparatively slight gain in weight efficiency that could be obtained with a multipolar type is more than offset by the increased complication of the windings. The only portions of the machine open to the outside air are exposed at the

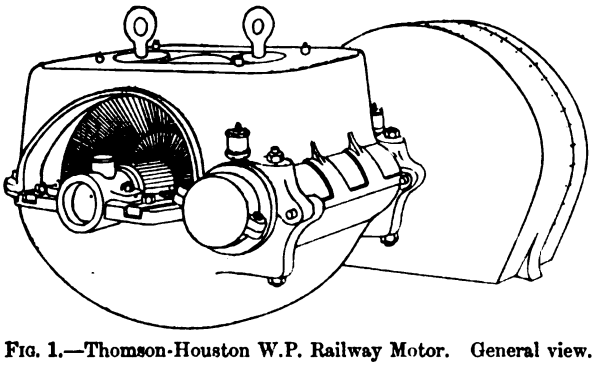

FIG. 1.—Thomson-Houston W.P. Railway Motor. General view.

two oval openings at the ends of the armature shaft, and even these can be easily fitted with covers should such a course prove desirable. The whole magnetic circuit is composed of two castings, bolted together, and free to swing apart by a hinge, allowing ready access to the armature.

Fig. 2 gives an excellent idea of the internal arrangements. The armature itself is very nearly 20in. in diameter, a very powerful Pacinotti ring nearly 6in. on the face, and of about the same depth. It is wound with comparatively coarse wire in 64 sections, with 14 turns to the section. Each coil is tightly placed in the space between two of the projecting teeth, and about the interior space the separate coils are closely packed, leaving only sufficient room for the four-armed driving spider.

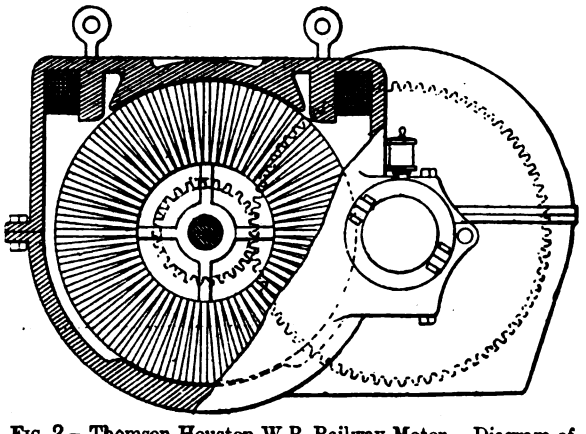

FIG. 2.—Thomson-Houston W.P. Railway Motor. Diagram of Magnetic Circuit.

As will be seen, the armature takes up most of the full height of the machine, the pole pieces being but trifling projections, and the requisite cross-section of iron being obtained by extending the poles to form a closely fitting iron box that appears in the exterior view. An unusual feature is the use of but a single magnetising coil wound not directly about the upper pole-piece but on the casing immediately surrounding it. The lower pole is but slightly raised, and both pole-pieces are of the greatest extent permissible with the dimensions of the machine. The use of a single magnetising coil produces naturally an unbalanced field and a strong upward pull on the armature tending to relieve the pressure on the bearings. The iron-clad form, however, tends to distribute the lines of force so as to avoid the sparking and change of lead that might otherwise have to be feared. The single coil is wound with quite coarse wire, and its position ensures the maximum magnetic effect from the current.

The speed of the new motor is about the same as that of the older S.R.G. form, but its general working efficiency is somewhat better, owing not so much to a greater maximum of efficiency as to a better working curve—at both heavy and light loads. The brush holders are shown in the cut (Fig. 1), and the slots in which they fit render their position evident. The brushes are of the ordinary carbon description, and are readily accessible through the opening at the end of the shaft.

In operation the W. P. motor has been highly satisfactory. It runs with but trifling sparking and no heating to speak of, gives a very powerful torque, and is singularly free from liability to damage of the armature, for which its careful insulation and the Pacinotti form adopted are responsible. It is now being regularly manufactured at the Thomson-Houston works, and it is expected to take with great advantage the place in popular favour of the R. S. G. motor that has made so good a reputation for itself during the past summer. It is an interesting departure, both electrically and mechanically, and aside from its special features its general qualities of iron-clad fields, gears running in oil, and the ease of access to the working parts, will commend it to the practical street railway man.

ELECTRIC RAILROADING IN THE CURRENT YEAR.*

Just before the convention of the American Street Railway Association at Buffalo a year ago, the *Electrical World* sent out a circular to electric street railway companies, asking for information on various points; and so useful was the result that a similar paper was sent out about a month ago for the purpose of obtaining certain facts regarding the operation of electric roads that might prove useful to street railway men.

At the last Street Railway Convention the first of the really slow-speed motors—that brought out by the Wenstrom Company—was exhibited. During the early months of 1891 all the principal manufacturers of electric street railway motors brought out single reduction machines, and two of them—the Westinghouse and Short Companies—devised gearless motors, which have not yet, however, been much more than experimentally worked. The Eickemeyer gearless motor should also be mentioned in this connection, although it has not been exploited so vigorously as the others. It was no small task to produce a durable and efficient railway motor possessed of an armature speed low enough to permit a single-gear reduction. The older motors were reasonably efficient electrically, but the armature speed was in the vicinity of 1,000 revolutions per minute. With the standard sizes of wheels in use on street cars, this armature speed had to be brought down to about one-third its usual value to permit of a single-gear reduction, and to one-tenth to allow gearless machines mounted directly on the axle to be used at ordinary speeds.

To accomplish either of these feats, retaining at the same time a tolerable efficiency, has been no easy matter. To produce the necessary turning effort on the axle a slow-speed motor armature must be constructed so as to have a torque very much greater, and its windings much more powerful than in the case of the old armatures. This increased torque has to be obtained by increasing the induction through the magnets, the number of armature turns, and the current through the armature; sufficient increase in any one of these will answer the purpose, but practically all three are necessarily varied, for in the effort to build a light-weight motor even the double reduction gear machines had the iron worked up practically to saturation, a large number of turns of wire on the armature, and a considerable current flowing through it. A certain gain can be made by constructing multipolar machines, thus making the armature wire in part do double service, but the help is not so great as might at first sight appear. A great deal of ingenuity was spent in combining the three factors of the torque in such a way as to obtain the best results. The multipolar construction has been rather a favourite, and the changes have been in the direction mainly of more powerful armatures, wound with more turns of wire and with coarser wire. So far as the single reduction gear motors are concerned, the problem has been solved with a fair degree of success; in fact, only one of those brought out within the year has proved so unsatisfactory as not to be adopted to any extent. When it came, however, to reducing the speed of the armature, not to one-third of its former value but to one-tenth, the difficulties were enormously enhanced, and in

* Abstracted from the *Electrical World*.

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neither of the designs brought out has it been thoroughly evident whence the enormous torque required can come. Both forms are reported to do well in comparatively light work, but what would be the results when tried on the same service now exacted of the standard motors it is impossible at present writing to say, as neither type has yet been adopted widely enough to permit any judgment based on everyday experience to be made.

The single reduction gear motors have in general proved an unqualified success, thus amply justifying the predictions of the result that have at various times been made. As regards the efficiency of these new types of machines, appearances indicate that rather more is saved in the gearing than is lost in purely electrical efficiency, so that the total result is rather better than with the old motors. The general adoption of the Gramme type of armature for this work has decreased armature repairs, and accompanying improvements in design have probably raised the mean working efficiency at least 5 per cent.; all this means better and more economical service.

As regards power station practice the indications are that it has improved. The tendency has been to the use of larger dynamos, large and more economical compound or triple expansion engines, and a better proportioning of the plant to the average power required. One marked change has taken place in car equipments; the double truck car exhibited and very much commended at the last convention has proved one of the forerunners of a considerable number of long electric cars provided with bogie trucks or with the excellent radial truck gear that has been recently introduced. Such cars have been rendered necessary by the requirements of electric service. So long as the speeds employed were comparatively low ordinary street car trucks or special forms designed better to support the motors proved quite sufficient for all requirements; as soon, however, as it became necessary to increase the speed considerably a fixed wheel base, comparatively rigid in spite of every effort at flexibility, becomes unsuited to the work, and in addition it is sometimes convenient to use large and very capacious cars. As a result of this a large number of companies are now running, more or less, the long electric cars; they are most serviceable on the larger roads, where they will seldom have to be run lightly loaded. Such cars have to a considerable extent replaced the regular employment of trail cars, although these are most convenient for handling an occasional increase in traffic.

Coming now to the reports received in response to our inquiries, the car mileage properly comes up for consideration. The average is not greatly increased over the figure 101 given by the average of last year's reports; the maximum car mileage, however, is noticeably high. The largest mileage reported was from a small Thomson-Houston road that had been in operation about three months. The President of the company stated that the cars made 175 miles a day, a figure a good deal in excess of the maximum found in last year's reports. Two other roads, a Sprague-Edison and a Westinghouse, both of small size, reported a daily car mileage of 160, while a considerable number reported from 125 to 150; from this the figures ranged down to 46 as the average day's run.

Comparatively speaking, so few roads, even now, are employing single reduction motors that the replies to the questions concerning the operation of these were not as extended as might have been wished. Reports, however, were received from one or more representatives of each of the following systems:—Edison, Thomson-Houston, Wightman, Sperry, Westinghouse, Sieberling, and Baxter. Every road reports entire success. In each case it is stated that the motors start well on grades (in one case noted as 7½ per cent.), do not heat much, seem to take about the same current as the old machines unless possibly a little more in starting, and can perform the heaviest service of the road in a thoroughly satisfactory manner. The reports are uniformly of the most encouraging character, and one or two superintendents wrote in detail to say that they were especially pleased with the performance of the new type of machine. One reports that the single reduction gear machines are working regularly over grades as high as 8 per cent., and sharp curves on inclines only a trifle less severe. Another road is in the habit of taking two trailers up a 6½ per cent. grade with a pair of 20 H.P. motors on the motor car. All this ought to be exceedingly satisfactory both to the street railway men and to the manufacturers of the machines, and leaves no question as to the success of the single reduction motor, which is bound to drive out the older types very rapidly.

The reports on repairs were of a rather singular character; they were surprisingly good, some of them almost too good, in fact. It is certainly very remarkable, for instance, to have a road operating 10 or 12 cars report no armature or field coils replaced or rewound, and no other apparatus disabled during an entire year's operation. On the other hand, the average result of the replies may not be far from correct, for one disgusted street car man reported the cost of repairs on the car equipments as probably reaching $1,000 per car per year. It is very difficult to get at the true cost of necessary repairs on motor equipments, because those who have suffered do not usually care to disclose the full extent of the injury. The reports received indicate, as might have been predicted, that the principal mortality is in armatures, at least three of these being seriously damaged to one field coil, rheostat, or switch-box, and the general tenor of the present reports seems to show that as regards armatures there has been perceptible improvement within the last year. Next year, thanks to the single reduction motors with their big Gramme armatures, the results will unquestionably be even more favourable than at present. The same is true in the matter of gears, for the open gear of the old double reduction motors was, and is, particularly subject to wear and breakage, owing to multiplicity of wheels and to free access of grit and dirt of every description. The later motors with single gears run in oil should, and undoubtedly will, show a very much lessened wear and tear and vastly decreased repair bills.

As regards systems other than the overhead lines, there is very little to say at present. A single storage battery road has been put into operation during the year, and that one is stated to have given very satisfactory results, although no detailed report was sent in. Several other storage battery roads are threatened, together with divers conduit roads of sundry descriptions, but none of them has materialised sufficiently to be given a place here. Altogether the past year has been fruitful in improvements in electric traction, and there are more to come. The directions from which they must be expected are the more general use of the single reduction motor, the improvement of the gearless machines so as to be thoroughly available—at least for light service—the increased use of long and capacious cars on large roads, the displacement of wasteful engines by more economical types of a size better suited to the work, and finally the invention of that ideal piece of apparatus for which every pious street railway man is devoutly praying—a lightning arrester that will effectively protect his dynamos.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, November 13th. (To-night.)

INSTITUTION OF ELECTRICAL ENGINEERS.

7 p.m. Annual Dinner at the Criterion Restaurant, Piccadilly.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' meeting. Papers to be read:—(1.) "Description of the Works on the Barking and Pitsea Extension Railway." By Henry E. Stilgoe, Stud. Inst. C.E. (2.) "Rail-Pile Bridges in Ceylon." By Harry Bucknall, Stud. Inst. C.E.

TUESDAY, November 17th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Papers to be read with a view to discussion:—(1.) "Portland Cement, its Manufacture, Use and Testing." By H. K. Bamber. (2.) "The Inspection of Portland Cement for Public Works." By A. E. Carey, M. Inst. C.E. (3.) "The Influence of Sea-Water upon Portland Cement, Mortar, and Concrete." By William Smith, M. Inst. C.E.

WEDNESDAY, November 18th.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary meeting. Papers to be read:—(1.) "Report on the International Meteorological Conference at Munich, September, 1891." By Robert H. Scott, F.R.S. (2.) "On a New Self-Recording Rain Gauge." By W. J. E. Binnie, B.A. (3.) "On Wet and Dry Bulb Formulæ." By Prof. J. D. Everett, F.R.S. (4.) "Results of Meteorological Observations made at Akassa, Niger Territories, May, 1889, to December, 1890." By Frank Russell, F.R.Met.Soc.

SOCIETY OF ARTS.

8 p.m. Ordinary meeting. Opening Address by the Attorney-General, Sir Richard Webster, M.P.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Special meeting to consider new bye-laws.

THURSDAY, November 19th.

INSTITUTION OF CIVIL ENGINEERS.

2 p.m. Students' visit to Messrs. Samuda Brothers' Works Poplar.

CHEMICAL SOCIETY.

8 p.m. A Lecture on "Colour Photometry." By Capt. W. de W. Abney, F.R.S.

FRIDAY, November 20th.

PHYSICAL SOCIETY.

5 p.m. Paper to be read:—"A New Theory concerning the Constitution of Matter." By Dr. C. V. Barton.

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PUPILS AND THEIR PREMIUMS.

The exact relationship between master and apprentice was well understood a century or so ago, when generation after generation of workmen passed through the same course. To-day their relative position is less well defined, not because the rules have become vague, but because new ones are continually invented and imposed by the trades unions. A century ago there was no such thing as the premium pupil, and to-day a specimen of the all-round millwright is hardly to be found. Engineering, then a trade, is now a profession; and the only method by which a professional engineer can learn the practical part of his business is to "go through the shops" as a pupil. Difficult as it may be to define the relations between master and apprentice, the position in which an employer stands towards a pupil is less easy to determine. A busy manufacturing firm generally finds that pupils are on the whole a great nuisance in the works. The foremen have not, as a rule, complete control over them; and while the indolent pupils are continually playing the fool, the industrious ones are felt to be sucking the brains of their employers, who can really only utilize their talents by taking them on as members of their staff. This being so, it is not to be wondered that premiums of £500 for a three years' course are not uncommon. And if pupils still come at that price, it is not surprising that the employers are content to put up with some inconvenience.

But these large sums, together with the vague conditions which are generally made and the absence of any definite status, have tempted many ingenious people to trade upon the pupil system; and we are glad, for the sake of the public, that one of the worst cases of this kind, one which has for some years been known to the trade, was at last thoroughly exposed by the action which is reported in our Legal Intelligence. We do

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not desire to dwell upon the disclosures, but propose to comment on the premium system; since this instance of grave abuse of it, instead of calling attention to the rather unsatisfactory state of the question, and to the directions in which improvement is possible, may be used as an argument against the general custom.

The opponents of the high premium say that it is a gross imposition to charge £300 to £500 merely for giving permission to a boy from school to prowl round among the benches and machines to pick up what he can. To this it may be answered, that the price of a thing is that which it will fetch. If a young man or his parents are desirous of doing the best that is possible to give him a good start, they will naturally turn to the leading firms; and these have three courses open to them: to reject all applications, as is done by some of the most important engineering establishments; to place the premium at such a figure that only a convenient number will be admitted; or to impose some other qualification, such as a certain proficiency in technical or theoretical knowledge. No one can grumble at the first, for there is no hope of hiding a trade secret from an inquisitive pupil; the last demands more trouble than most manufacturers are disposed to give, and we are thrown back upon the stiff premium.

To the definition of "the price of a thing," to which we have already alluded, must be added the warning, "*caveat emptor.*" Although an extremely high value attaches to the privilege of passing three years in the works of a large engineering firm, it must be remembered that a pupilage in the best firm in the country need not necessarily give a *cachet*, and the premium cannot strictly be regarded as an investment. We are not aware that a University degree is worth the proctor's fee to an engineer; but that is not any argument whatever against a University education, although it may cost nearly £1,000. On leaving the works, where he may or may not have made the best of his time, the young engineer will find himself in competition with those who have been turned out of some Technical College, with formulæ at their fingers' ends; while he, perhaps, has left one of his behind him at the factory—a finger end we mean, not a formula. It all depends on himself whether he can make better use of his practical experience than the other man can make of his theoretical knowledge. It is now generally conceded that at least a year or two in the lecture-room and laboratory should precede the entrance to the factory. The excellent technical education that is to be had to-day enables the term of pupilage to be reduced, and the premium naturally bears some proportion to the term. This reduction is alluded to in the admirable publication which has been recently issued by the Institution of Civil Engineers under the title of "Engineering Education in the British Dominions." But the payment of a premium should not be considered as a mere solatium for the trouble of having pupils about the works; and it would be quite possible to check larking, if not cigarette-smoking inside boilers, &c., by allowing pupils more frequently to do responsible work in which they would feel that they were of some use, and to make such occasions conditional on good behaviour. On the other hand, the "industrious apprentice" often finds that he is only allowed to learn, while wishing to be really taught. But a preliminary technical education will open his eyes to the directions in which he will learn most; and a little tact and a well-placed shilling or two besides his "footings" will put him in possession of all that his employer *cares that he should know.*

When a high premium is paid the employer should, we think, be more generous as to the range of information to which his pupils are allowed access. To learn engineering as a profession and to learn it as a science are two distinct matters, which differ only by the introduction of the commercial element. It is customary, we believe, to withhold from pupils all information as to cost of production, prime costs, &c. Unlike an articled architect, he very rarely sees a specification, estimate, or form of tender; and the whole commercial part of the business has to be learned afterwards, perhaps by bitter experience, which may cost far more than a dozen premiums. With a high premium, it becomes a duty on the part of the employer to give a pupil some chance of learning the elements of the commercial side of the business; and some facilities, even though they may take the form of inspection of prices of old and byegone jobs, or model dummy prime costs and specifications, should be granted. The other extreme is reached when pupils are taken on the understanding that they are going to learn engineering, but are kept in the office to do ordinary clerks' work. Fortunately, this is rare, the results probably leading to anything but a saving to the employers. We have heard of a case where pupils were not allowed to take any part whatever in the testing of dynamos.

So far we have not alluded specially to electrical engineering, since the greater includes the less. The ideal training is to go to a general engineering firm before taking up the electrical branch of the profession. Since only about half of those who turn to engineering after leaving school stick to it afterwards; and as it is difficult for a lad to make up his mind whether he will be an engineer or no, it must be still more difficult for him to decide upon a particular branch. The custom of paying £100 a year is more frequently to be found in electrical engineering, and one excellent result is that it allows a pupil to change his mind if he finds the work distasteful. The electrical engineer has, as a rule, much more occasion for the services of a technically trained staff than his purely mechanical *confrère*, and he will naturally make considerably more use of the most intelligent and industrious of his pupils. His responsibility towards them is therefore the greater; and we hope that the gross abuse of the pupil system which has been disclosed will be a warning to parents, and remind engineering firms that they should do something more for their pupils than pocket their fees and get as much useful work out of them as possible.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 716, Vol. XXVII.*)

§ 29. **Comparison of Galvanometer Constants.**—If we have a large standard coil whose dimensions have been carefully determined we may employ it to find the galvanometer constant of any other coil whose constant, either on account of the small size of the coil or the comparatively large space occupied by its windings, cannot be accurately calculated. Let G_1 be the galvanometer constant of the standard coil, G_2 that of the other coil. Place the two coils with their centres coincident, and their planes parallel to one another and to the magnetic meridian. Suspend at the common centre a very small magnet, with a mirror attached. The motion of the mirror is observed by a lamp and scale in the usual way. If currents are now sent round the two coils in opposite directions it will be possible, by properly adjusting the currents, to make the magnetic force at the centre due to the two currents vanish. When this is the case no deflection will be observed when the two currents are sent round the coils.

Let the coils be joined up as shown in Fig. 30, and let the resistance of the portion A G_1 B be R_1, while that of the portion

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A G_2 B is R_2. Then the currents i_1 i_2, flowing through G_1 and G_2, are proportional to $1/R_1$ and $1/R_2$. If no deflection of the suspended mirror is produced, then $G_1 i_1 = G_2 i_2$, or $G_1/R_1 = G_2/R_2$. Thus, by the comparison of two resistances we can compare the two galvanometer constants. The difficulties to be overcome in making an accurate determination of the ratio R_1/R_2 are purely those connected with Ohm's law, and we shall not deal with them here.

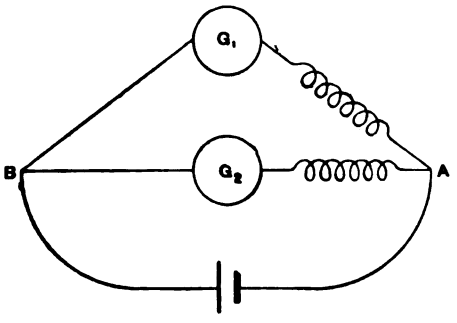

Fig. 30.

If suffixes 1 and 2 refer to the standard coil, and to the other coil respectively we have

$$\frac{G_1}{G_2} = \frac{R_1}{R_2} = \frac{n_1}{n_2}\,\frac{a_2}{a_1}\,\frac{1 + \frac{1}{3}\frac{h_1^2}{a_1^2} - \frac{1}{2}\frac{k_1^2}{a_1^2}}{1 + \frac{1}{3}\frac{h_2^2}{a_2^2} - \frac{1}{2}\frac{k_2^2}{a_2^2}}.$$

In some cases we wish to know the mean radius a_2 of the second coil in terms of that of the standard coil. We have then,

$$\frac{a_2}{a_1} = \frac{n_2 G_1}{n_1 G_2}\,\frac{1 + \frac{1}{3}\frac{h_2^2}{a_2^2} - \frac{1}{2}\frac{k_2^2}{a_2^2}}{1 + \frac{1}{3}\frac{h_1^2}{a_1^2} - \frac{1}{2}\frac{k_1^2}{a_1^2}}$$

If h_2, k_2 are small compared with a_2, then an approximate knowledge of h_2 k_2 and a_2 will enable us to obtain a very accurate value of a_2. The limit to the accuracy of this method is chiefly that imposed by the exactness of our knowledge of the relative resistances of the resistance coils used.

§ 30. **Electro-Magnetic Force on a Conductor.**—We proved in §20 that the mutual potential energy of any magnetic system and a magnetic shell was equal to the strength of the shell multiplied by the number of lines of induction due to the magnetic system, which would, if the shell were non-magnetic, pass through the shell in the opposite direction to those actually proceeding from the shell itself. Having proved the equivalence of a current and a magnetic shell, we can restate this result as follows:—The mutual potential energy (in ergs) of a closed current and any magnetic system is equal to the strength of the current multiplied by the number of lines of induction, which would, if the current were not flowing, pass through the circuit in the opposite direction to those actually due to the current. If we call N the number of lines through the circuit in the *same* direction as those due to the current itself, and i the strength of the current, then the mutual potential energy will be $-Ni$ ergs. The magnetic system may consist either of magnets or of currents in closed circuits.

From this result we can easily find the mechanical force acting upon the circuit in any direction. Let x (Fig. 31) be the distance of some point, P, rigidly connected with the circuit, from a fixed point, O, measured along the straight line O P Q. The circuit being kept parallel to itself, let it be moved so that P comes to Q where O Q $= x'$.

Let N be the number of lines of force due to the magnetic system passing through the circuit in the *same* direction as those due to the current itself, when the circuit is in the position defined by x. Let N′ be the number corresponding to x'. The values of the mutual potential energy of the magnetic system and the current in the two cases are $-Ni$ and $-N'i$ ergs. The potential energy has been increased by the motion from x to x' by the amount $-(N'-N)i$ ergs; in other words, this is the amount of work spent by external agencies in moving the circuit from x to x'. The force exerted by these agencies upon the circuit in the direction in which x increases is accordingly $-\frac{N'-N}{x'-x}i$ dynes. The mechanical force experienced by the circuit in consequence of the action of the magnetic system is equal and opposite to this, and is therefore $\frac{N'-N}{x'-x}i$ dynes. In the notation of the differential calculus we may write $X = i\,d\,N/d\,x$; X being measured in the direction in which x increases. Hence,

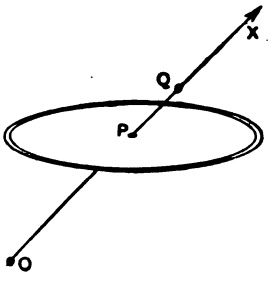

Fig. 31.

when N increases with x the circuit experiences a force tending to make x increase. Thus, if the circuit can move it will move so as to increase the value of N. Or we may say that the circuit tends to place itself so that the number of lines of induction passing through it is the greatest possible. If we bear this principle in mind we can at once understand all the forces experienced by currents when placed in a magnetic field.

§ 31. **Electro-magnetic Force on an Element.**—We will now investigate the force experienced by each portion of the conducting circuit when it is placed in a magnetic field. Take any circuit as in Fig. 32, having a sliding piece, P Q, sliding on two parallel wires one centimetre apart. Let a current i traverse the circuit in the direction indicated by the arrows. Now place the circuit in a magnetic field so that the lines of induction of the field near P Q are at right angles to the plane in which P Q moves, and in the direction going from the reader towards the paper. Let P Q be moved to P′ Q′ through a distance x. Then if the number of lines of induction due to the magnetic field per square centimetre of the plane in which P Q moves is **B**, the whole number of lines of induction which have been made to pass through the circuit in the same direction as those due to the current itself by the motion of P Q,* is $\mathbf{B}x$.

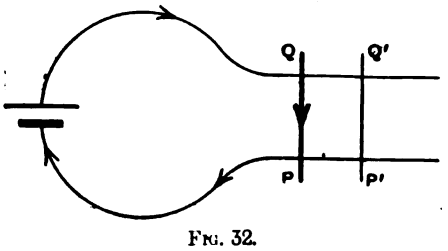

Fig. 32.

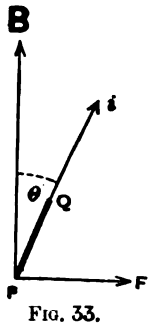

Fig. 33.

The work spent by external agencies upon the slider during its motion is therefore $-\mathbf{B}xi$ ergs. Hence the force experienced by the slider is in the direction P P′, so that if the slider is free to move it will move in that direction. The magnitude of the force on the unit length is $\mathbf{B}i$ dynes. We see also that the slider moves so as to increase the number of lines of induction passing through the circuit. If now the magnetic induction had not been at right angles to the wire at P Q, it is clear that only that component of the magnetic induction which is perpendicular to the wire can have any effect in changing the number of lines of induction through the circuit when the small portion P Q moves. Let θ be the angle between the direction of **B** and the direction of the current (Fig. 33). [P **B** and P F are in the plane of the paper, P Q is in a plane through P **B** at right angles to the paper, and its direction is *from* the reader.] Then the magnetic

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induction perpendicular to the current P Q is $\mathbf{B} \sin \theta$. Let the two wires upon which P Q slides be placed so as to be at right angles to the plane containing the directions of **B** and P Q. The variation in the number of lines through the circuit due to the motion of P Q will then be the most rapid possible, and consequently the direction of the electro-magnetic force experienced by P Q will be along these wires, *i.e.*, at right angles to the plane of **B** and P Q. The resultant force experienced by the sliding piece is therefore $F = \mathbf{B} i \sin \theta$ dynes per centimetre of its length at right angles to the planes of **B** and i. The consideration of the first case will show that the direction of F is along P F, and is related to the directions of **B** and i in the following way. If a right-handed screw is placed with its axis along the direction of the force, then a rotation in the direction from i to **B** makes the screw advance in the direction of the force. Another way of remembering the direction of the force is the following. Imagine an observer placed so that the current runs from his feet to his head. Let him then turn round till his right hand points in the direction of the magnetic induction. The force acting on the conductor is then such as to make him move forwards. This rule is easily remembered, and is of great assistance in finding the direction of the force experienced by the current. The quantity $\mathbf{B} i \sin \theta$ is the area of the parallelogram formed on **B** and i as sides; it is the vector product of the two vectors i and **B**.

An important point arises as to the determinateness of the action experienced by an element of the current when placed in a magnetic field. If we examine the process described at the beginning of this paragraph, we see that it consists not only in increasing the area of the circuit by the area PQQ'P', thus increasing the number of lines of force due to the magnetic field which pass through the circuit, but also in producing the extensions of the current represented by PP' and QQ'. Unless we are prepared to affirm that the creation of a current in the two portions PP' and QQ' while they are under the influence of the magnetic field involves no expenditure of energy, we are not entitled to state that the force experienced by the element ds is the vector product of $i\,ds$ and **B**. If we move the circuit so that we introduce no new parts, then this difficulty disappears, and the force experienced by the circuit as a whole will be the same as if forces represented by $\mathbf{B} i\,ds \sin \theta$ were applied to each element of the circuit at right angles to the plane of **B** and $i\,ds$. If we wish to increase the area of the circuit by a given amount, we can either make PQ small and PP' comparatively large, or we can make PP' small and PQ comparatively large. When PQ is small so that it approximates to a true "element," the uncertainty arising from the extensions PP', QQ' will be large, while when PQ is large the uncertainty will be very small since PP' is very small. But when PQ is large compared to PP', it may be regarded as having made a considerable step towards its development into a closed circuit. This illustration helps us to understand the statement that although we can assert positively that the action experienced by a closed circuit in any magnetic field is the same as if forces $\mathbf{B} i\,ds \sin \theta$ were applied to each of the elements of the circuit, still the action experienced by each element is really indeterminate. We shall never fall into any error in taking $\mathbf{B} i\,ds \sin \theta$ as the force experienced by an element provided that we extend our calculations to the *whole* of the circuit. This limitation is really no hardship, since all circuits in nature are closed.

(To be continued.)

THE COLOGNE AND DÜSSELDORF MUNICIPAL CENTRAL LIGHTING STATIONS.

(FROM OUR GERMAN CORRESPONDENT.)

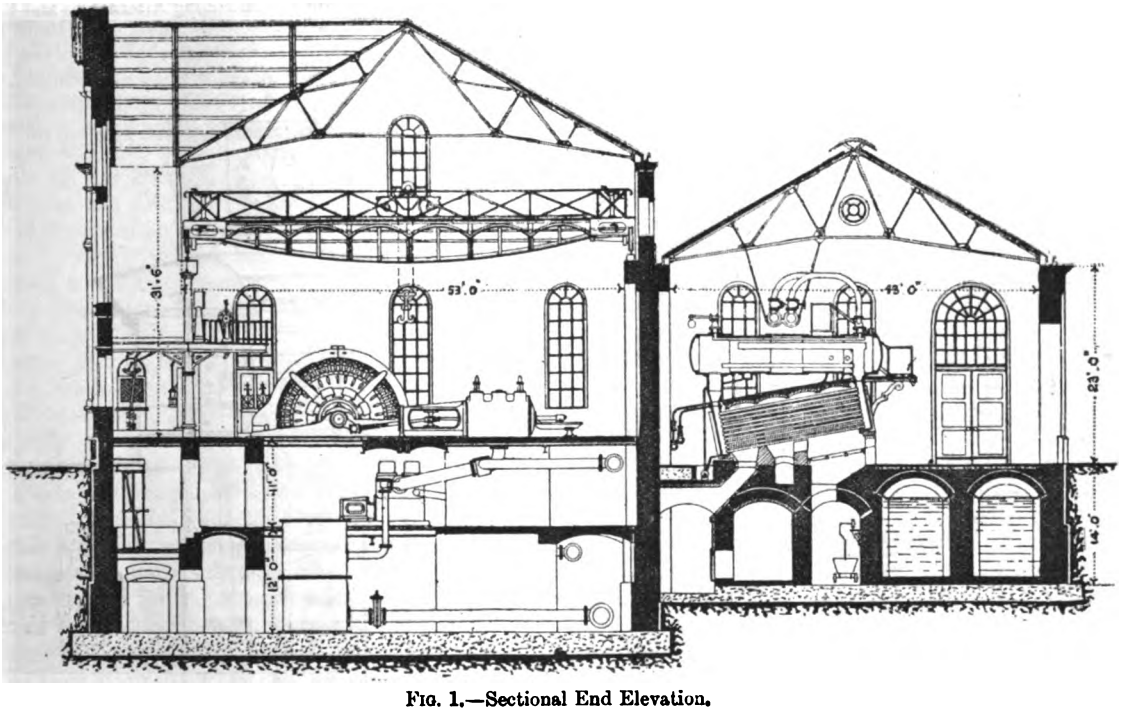

FIG. 1.—Sectional End Elevation.

The Cologne central station, of which the accompanying illustration (Fig. 1) shows a section, is situated at the side of the Municipal Gas and Waterworks, and is, in fact, under the same administration. This is a good plan—saving, as it does, the expenses of a separate administrative staff, and rendering possible the supply of steam to the engines of the electric central station from the boilers of the Waterworks during the hours of light load.

The boiler-house, which is 152ft. long and 43ft. across, contains five pairs of Steinmüller boilers, each of 1,650 square feet heating surface, and working at a pressure of 114lbs. per square inch. Below each ashpit there is a shoot running to a tunnel, in which are small trucks, which, after being filled with the ashes, may be run out into the yard. The engine-room is the same length, but 53ft. broad and considerably higher. It contains, at present, two 600 H.P. Sulzer compound condensing engines, and one 125 H.P. Sulzer engine, also compound, and provided with a condenser. These engines (Fig. 2), the shafts of which

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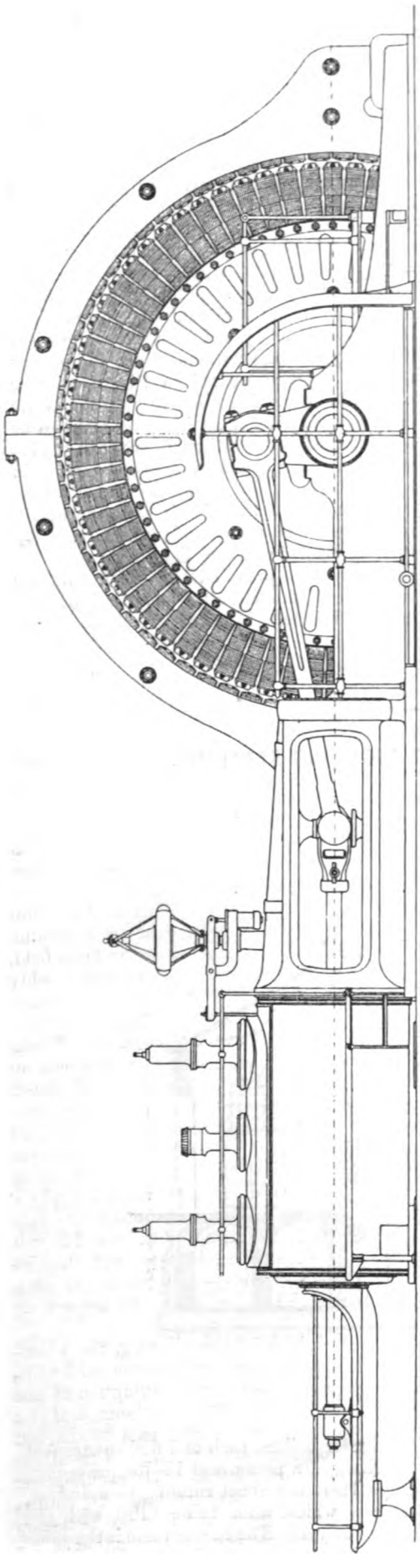

FIG. 2.—600 h.p. Sulzer Engine, coupled direct to Zipernowsky Alternator.

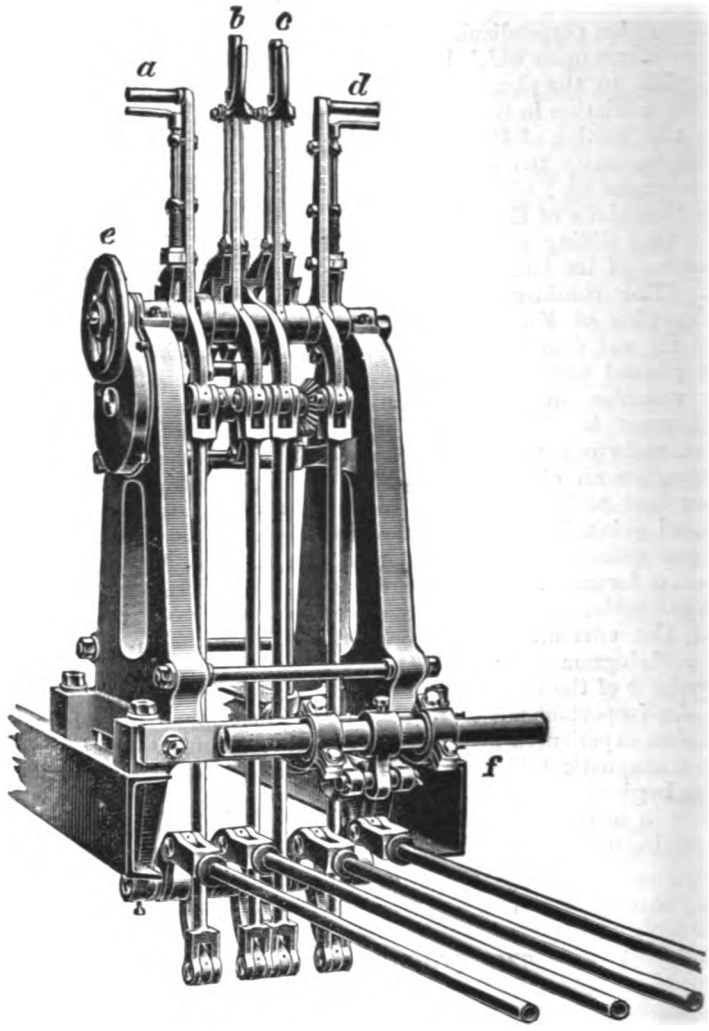

FIG. 3.—Switch Mechanism controlling Alternators and Exciters.

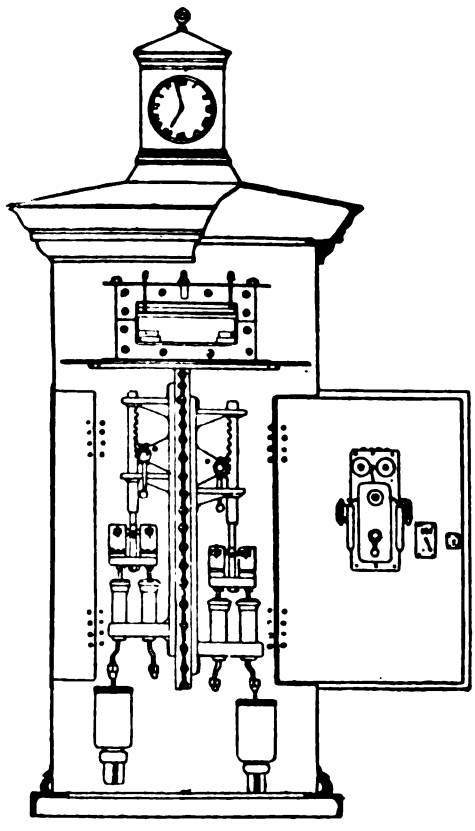

FIG. 4.—"Disconnecting Column."

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carry the hubs of the magnet-wheel of the alternators, run at 85 revolutions, requiring, therefore, 72-pole alternators to give 50 complete cycles per second. The spindles of the magnet-wheels also carry the ring armature of an eight-poled exciter, the field-magnets of which are attached to the stationary armature of the alternator by means of four cast-iron arms. These arms and the spindle are, in fact, the only cast-iron parts of these dynamos, if we leave out of view the large ring-shaped frame to which the armature coils of the alternator are attached in the well-known Zipernowsky manner. The field-magnets of the exciters, although ring-shaped and containing eight radial polar projections, are wholly built up of iron sheets, half a millimetre (20 mils.) thick, and of half-ring shape, the polar projections being cut out by means of boring and slotting machines, after the whole of the field has been first screwed and then riveted together. The weight of iron in the exciter armature is nearly 1 ton 2cwt. for the 600 H.P. dynamo, and about 14cwt. for the 125 H.P. dynamo. The weights of copper are respectively about 6½cwt. and 4½cwt. upon the armatures, and 13cwt. and 9½cwt. upon the field-magnets of the exciters; these are shunt-wound for the 125 H.P. dynamo and compound for the large dynamos. In spite of the low speed these dynamos have an electrical efficiency of 93 and 89 per cent. respectively, and a commercial efficiency of 90 and 85 per cent., including the exciter. In Fig 1 a 25-ton travelling crane is also shown. This crane can travel through the whole length of the engine-room. The magnet-wheel of the alternator and the armature of the exciter, which is attached to the former, can be moved laterally so far that the parts of each may be easily got at, this lateral movement being made by means of sliding bars and a hand-wheel.

I now come to the description of that part of the central station which distinguishes it from all others which have been erected so far. The extreme simplicity of handling all these dynamos, combined with the want of all visible connections which could annoy the mind of the mechanical engineer, are certainly a decided advance; this central station is not a labyrinth of hundreds of bare or insulated conductors, but rather a simple looking machine station, the control and regulation of which is effected by a simple mechanism moving a couple of levers. These lever mechanisms, of which Fig. 3 is an elevation, are due to Herr Carl Coerper, the managing director of the Helios Company of Cologne, which erected this station. Two such arrangements have been exhibited at Frankfort.

The method of introducing one alternator into the circuit to work in parallel with one already running is as follows:—Lifting the handle of the bolt (Fig. 3), we move the lever *d* until the bolt fits into the first hole. We have in this way completed the field-circuit of an exciter. We now proceed to regulate the excitation by slowly moving the second lever *c*. The field having attained a suitable degree of excitation, we close the main circuit of the exciter, *i.e.*, the field of the alternator, by moving lever *d* to the last notch of the sector. Then by taking resistance out of the field circuit of the alternator by moving lever *b*, we excite it to its normal pressure. So far no damage could have been done if any of the levers had been handled wrongly or in the wrong order. To avoid any damage being done by an inattentive man, Herr Coerper has employed a locking device which renders it impossible to introduce the dynamo directly into the lamp circuit. By moving lever *a* to the first slot in its disc, we complete the circuit of the load of resistances, and we must now turn the wheel *e* before we can go on with our lever. By doing so we introduce more and more resistance, and only now can we move *a* to the next position, when this resistance and the lamp-circuit are in parallel. We then have to turn *e* backwards, and after having wholly taken out the resistance load, we move the lever to its last position, when the dynamos will be working in parallel with the others upon the town circuit.

I have now to mention the fourteen "disconnecting columns," by means of which any part of the whole network may be disconnected, thus allowing new portions of cable to be joined or new house junctions to be made, which is necessary as there is no secondary network at all in this town. Fig. 4 shows one of these columns designed for use at Amsterdam, containing four mercury switches and cable ends, an alternating current clock, and a small telephone station, which allows of communication between these "disconnecting columns" and the central station. For this purpose about three and a-half miles of telephone cable have been put down with the eleven miles of concentric cable. The columns adopted at Cologne are minus the clock.

The cables are placed in wooden troughs in which they are supported by iron hooks, the troughs are filled with molten asphalt and then covered with a layer of bricks and sand. The cables, which were furnished by the Société d'Exploitation des Câbles Électriques (Système Berthoud, Borel et Cie), of Cortaillod, Switzerland, are moreover protected by lead and iron sheathing. Each length of 200 to 300 yards has been tested at double the working pressure, namely, to 5,000 volts, between the two conductors, and between the exterior conductor and the lead cover. The insulation resistance of the whole network, measured with 100 volts, and a mirror galvanometer, was found to be 1,000 megohms per mile.

The supply network is calculated for a maximum output of 20,000 16 candle-power lamps, burning simultaneously. The first portion of the plant, comprising two 500-600 H.P. dynamos, and one of 125 H.P., will, however, soon be too small. Since the opening of the station at the commencement of September, 200 house connections have been made, and about 100 transformers have been installed, the total primary current being at present about 45 amperes, equal to about 1,600 lamps burning, and nearly 6,000 installed; and this number will certainly be greatly increased as Christmas approaches.

The transformers (Fig. 5) which contain three secondary terminals with a potential difference of 36 volts between an exterior and the middle terminal, or 72 volts between the two exterior ones, have been built for this low pressure to avoid great losses in the resistances for arc lamps, the Helios Company having succeeded in turning out an alternate current arc lamp giving a white and steady light, and running off 36 volts, including resistance. For this reason the three-wire system is employed in most cases of house-wiring for the arc lamp leads, two wires being in use for the incandescent lamps. The terminals of the transformer are put out of the reach of private persons by means of a metal case, not shown in the figure, which represents a 10-kilowatt transformer. This size is generally used for large houses, or cases where two or three small houses are joined to one transformer.

The electric meter (Fig. 6) adopted is the Bláthy. The shunt field, on account of its high self-induction, reaches maximum magnetisation about a quarter of a period after the main field, and when at zero magnetisation produces powerful eddy currents in a rotating aluminium disc. This eddy current moves in such a direction that it is attracted by the main field, which, at this time, possesses maximum magnetisation. When, on the other hand, the main field equals zero, it produces an eddy current in another part of the disc, which is displaced from the point where the shunt field's eddy currents are generated by a quarter of the disc's circumference, the main field eddy current being besides in such a direction that repulsion takes place between it and the shunt field, which is very strong at this instant. A continuous rotation, therefore, takes place. The committee which tested the Bláthy meter about one year ago at Frankfort found that it started with one 100-volt 16 candle-power lamp, that is, with 0·5 ampere, and that its rotation continued to be proportional within three per cent. throughout its range, that is, from less than one ampere up to 100.

As to the central station's rules for house-wiring, the principal points are the following:—The working pressure is 72 volts, and the wiring has to be carried out on the assumption of one ampere being required for each 16 candle-power lamp, and of a loss of one volt from the transformer terminals to the last lamp, when all the lamps installed are burning. This allows 20 candle-power lamps to be inserted instead of 16 candle-power lamps, without passing the limit of one volt loss. Of course, this results in somewhat stout leads, and it is not necessary to limit the maximum current density to two amperes per square millimetre (1,300 amperes per square inch) as for long leads, this load can never be attained with a loss of only one volt. The insulation resistance of the whole installation

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has to be 1/C of a megohm, C standing for the current required by the respective installation. No wire is to be placed below a ceiling or a floor, unless lead-covered, and iron-armoured concentric cables are employed for this purpose. The smallest safety fuse must melt at six amperes, and all fuses have to be double poled. For testing the installation before connection to the network the consumer has to pay about 1s. per lamp up to 50 lamps; from 50 up to 500 lamps the sum decreases rapidly, since for 500 lamps £8. 6s. (166 marks) has to be paid. Transformers and meters, as well as the short end of primary cable from the network into the cellar of the consumer's house, are the property of the municipality. For the meter there is the same annual payment as for gas meters, that is 10s. to 20s. For every lamp installed, be it arc or incandescent lamp, the consumer has to guarantee a mean annual utilisation of 300 hours. The price charged is 8 pfennigs per 100 watt-hours (9½d. per B.T.U.). To large consumers there is, of course, a rebate. The largest consumer, except the theatre, which is not yet connected to the station, will perhaps be the old signalling and telephone lines. The sub-stations, of which the largest contains 140 Tudor accumulators with a discharge current of 1,000 amperes, contain also the regulating devices by means of which cells are disconnected or joined in order to keep the volts constant. From the sub-stations, the accumulators at which will be kept in order by the manufacturing firm of Hagen for ten years, the feeders and distributing leads are laid upon the three-wire system. The network is calculated for 25,000 lamps, and there are already demands for the equivalent of 15,000 16 candle-power lamps, of which about 10,000 are already installed.

The consumer has to bear the costs of connecting-up unless he has subscribed by November 1st for three years, in which case the municipality will bear the cost. The consumers pay monthly for a meter up to 15 lamps of 16 candle-power, one shilling; for a 30 lamp meter, 1s. 6d.; for a 60 lamp meter, 2s. 3d.; for a 100 lamp meter, 3s., and for every additional 100 lamps one shilling more. For 100 watt-hours the charge is 9 pfennigs (11d. per B.T.U.). If, however, the consumer

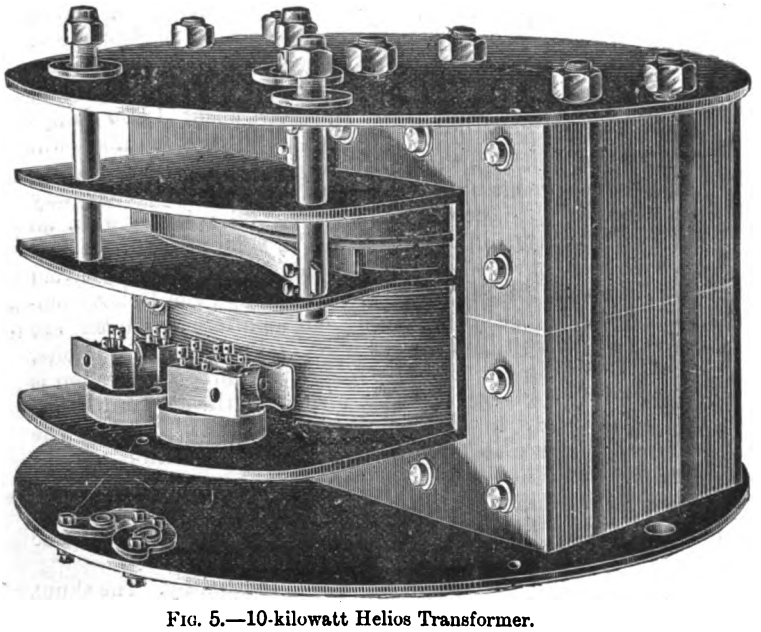

Fig. 5.—10-kilowatt Helios Transformer.

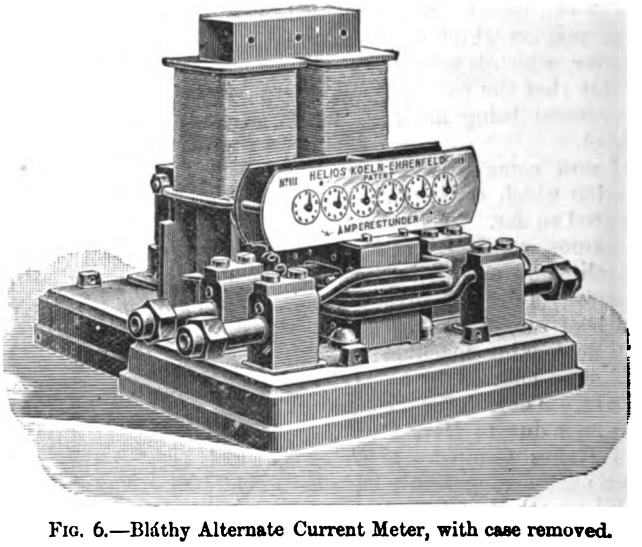

Fig. 6.—Bláthy Alternate Current Meter, with case removed.

"Gürzenich," where over 800 lamps are to be installed by the Helios Company.

The following are some additional particulars with regard to the Düsseldorf municipal central station, which was opened on October 24th, and of which you had a brief account in your issue of October 30th. The whole work, which was carried out by Messrs. Schuckert, of Nuremburg, comprises a central station and three sub-stations. The station itself, situated near the municipal gasworks, and covering an area of 10,760 square feet, comprises two engines of 300 effective H.P., running at 90 revolutions and coupled direct to disc armature dynamos. A third similar machine will soon follow. The engines are horizontal tandem machines, working with a pressure of 114lbs. per sq. in., and were constructed by the Sächsische Maschinenfabrik, of Chemnitz. The disc-armature dynamos give 1,000 amperes at 350 volts. The discs have a diameter of 10 feet, and have a peripheral velocity of nearly 2,600 feet per minute. The magnetic field is a cast-iron shell, provided with 28 polar projections. The diameter of the commutator is 6½ feet. Steam is furnished by two water-tube boilers of 1,650 square feet heating surface, constructed by the Hohenzollern Company, of Düsseldorf; a third similar boiler forms a reserve. From the station there are six feeders to the sub-stations, two for each, whose mean lengths are about 1½ miles. The feeders as well as the distributing mains, which have a total length of 88 miles, have been furnished by Messrs. Felten and Guilleaume, of Mülheim, are laid side by side in trenches about 3ft. 3in. deep, which are filled in with a layer of yellow sand and then protected with iron plates. Between the central station and the sub-stations there are

pays more than £10 (200 marks) annually for current a discount is granted, which is

4	per cent.	on	everything	over	and above	200	up to	1,000 marks.
8	,,	,,	,,	,,	1,000	,,	2,000	,,
12	,,	,,	,,	,,	2,000	,,	3,000	,,
16	,,	,,	,,	,,	3,000	,,	4,000	,,
20	,,	,,	,,	,,	4,000	,,	5,000	,,
24	,,	,,	,,	,,	5,000 marks.			

POLYPHASE CURRENT MOTORS.

The question of polyphase currents and rotary field motors, says our Paris correspondent, being the order of the day, although but few persons in France have up to the present studied it, M. E. Hospitalier read a lengthy Paper on the subject on Thursday last week before the Société Internationale des Électriciens, with a view of saving those who are interested in the matter the labour of personal investigation. M. Hospitalier described with his customary clearness the methods of generating and utilising polyphase currents, and explained their advantages and disadvantages. The polyphase currents generally used were, he said, either two-phase, lagging a quarter of a period, or three-phase, lagging a third of a period. In the first case three wires at least were necessary, one being larger than the other two; in the second case, three wires were also required, but they were all of the same diameter. At any instant the algebraical sum of the ordinates of the three sine curves was zero, and consequently any one of the currents might be considered to be the sum of the other two.

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Production.—To generate a three-phase current it was only necessary to take three coils each ⅓rd of a period in advance of the other, and revolve them in a uniform magnetic field. M. Hospitalier then described the Lauffen generator. The three groups of coils could, he remarked, be arranged in two different ways, viz, either in a star Y or in a triangle Δ. The star grouping had been adopted for reasons of safety. For experimental purposes it was possible to make a three-phaser by merely taking a Gramme alternator, with revolving field-magnets, and suitably connecting up the fixed armature coils.

Transformation and Transmission.—M. Hospitalier next described the Lauffen-Frankfort three-core transformers, intended to step the volts up from 50 to 15,000 at Lauffen, and step them down in the same ratio at Frankfort. He laid stress on the advantage of the star method of grouping the coils. The common junction of the three coils was, he pointed out, always at zero potential. It could, therefore, be earthed; and, in fact, in the case of the Lauffen-Frankfort transmission, the central point of the generator coils, of the high-pressure transformer coils, and of the low-pressure transformer coils, were all earthed with great care. A short circuit between primary and secondary would, therefore, cause the fuses to go immediately.

Utilisation.—Polyphase currents, in M. Hospitalier's opinion, lend themselves more readily than ordinary alternating currents to applications of a calorific, mechanical, or chemical nature. To bring out the peculiarities of three-phase currents, M. Hospitalier arranged three glow-lamps star fashion, the three external terminals being joined to three wires coming from a three-phaser. The equal brilliancy of each of the three lamps showed that if the currents in the lamps were not equal at any instant, their effective luminous intensities were. Polyphase current motors were, the lecturer said, based on the employment of rotary field generated by three currents sent through three circuits. The resultant field is constant, and revolves at a uniform speed. If a closed circuit is placed within such a field, alternating currents will be generated, and it will rotate in the same direction and at nearly the same speed as the field. As an illustration three flat coils, placed 120deg. in advance of each other, and having a magnetic needle at the centre, were shown. When a three-phase current was passed through the coils the needle rapidly revolved, and quickly changed direction when the current in two of the coils was reversed. The Brown motor was explained in detail, a little motor on this principle being exhibited and worked. The field magnet was a Gramme ring armature, connected at three points to wires coming from a three-phaser. In the centre of the Gramme ring was an armature, consisting of insulated copper bars buried in a laminated iron cylinder, all the bars being joined in parallel by two bronze discs keyed to the spindle. The rapidity with which the direction of rotation was changed when the direction of the current in two of the coils was reversed, was very remarkable.

M. Hospitalier then dwelt on the apparatus shown at Frankfort by Herr Schuckert, and which the lecturer christened "Continuous-current, alternate-current, three-phase motor-generator." This machine consists of a Gramme dynamo, on the spindle of which (at the opposite end to the commutator) there are three rings joined to three points of the armature 120deg. apart. This combination may be said to have six different functions according as it is supplied with mechanical energy, a continuous current, or a three-phase current, since if we give it one of these components it turns out the other two. It was a machine of this kind, built by M. Hillairet, that M. Hospitalier made use of for his experiments. A continuous current was supplied it, and it gave out mechanical energy and three-phase currents.

In conclusion, M. Hospitalier spoke of two-phase currents, of the system employed by Herr Schuckert for transforming and transmitting two-phase currents using three wires, and of the future of polyphase currents. Three-phase currents, he said, allow us to employ motors, having no collector, no commutator, no brushes, and possessing a maximum torque on starting. These advantages were particularly interesting in view of their possible application to mining machinery. The necessity for three wires rendered the application of the three-phase system to tramways out of the question. On the other hand, important researches were being carried out at that moment to obtain the same results with two wires, but the idea was not as yet sufficiently matured to say more at present.

LEAD "GALVANISING."

"Galvanising" as ordinarily understood is a somewhat misleading term. It has for all that a substratum of fact, having been evolved from a consideration of the electrical relations of zinc and iron. (The best process of galvanising iron is, indeed, to deposit a thin coating of tin electrically, before immersion in the melted zinc, but it is seldom used.) When applied to a method of coating iron and steel with lead it becomes remarkable rather as illustrating the growth of a technical word than as being particularly apposite. As many of our readers may be aware, there have lately sprung into existence several processes for protecting iron and steel by means of a covering of lead, instead of zinc, tin, or terne, some at least of which promise to oust the older methods from a good many of their applications.

One of these lead-covering processes is being brought out by an English syndicate working on lines which are said to have been successfully followed in America for the last three or four years. A fair-sized experimental plant has been set up at Messrs. Westwood and Company's works at Millwall, sufficient to show something of the capabilities of the process even to those more accustomed to judge of the probable success of a new undertaking from the results it gives when conducted on a small manufacturing scale, than from those obtained by a properly devised series of laboratory tests. The method itself may be described quite briefly: The actual coating of articles of iron or steel is effected much as in common galvanising, save that the bath consists of lead instead of zinc. It is in the preparation of the sheets, &c., before coating that the individuality of the process consists. In place of the ordinary pickling bath for removing scale and dirt, one is used composed of a mixture of hydrochloric and hydrofluoric acids, 10 per cent. of the former and 1 per cent. of the latter being employed. In this bath the removal of the scale is hastened by making the articles to be treated the anode of a weak current passing through the tank. On the strength of this arrangement the process had the term "electro" tacked to its name; but the intrinsic absurdity of such an affix having become plain to its proprietors the offending epithet is now in process of suppression. Although, perhaps, this is as well, yet it may be noted that a substantial advantage appears to accrue from the use of a weak current under these conditions, a saving in time of about one-third of that otherwise requisite being attained; we draw attention to this point because we consider that in many industries a similar utilisation of the selective and transferring powers of electrolysis might well be made, provided the adapters do not kill the enterprise by describing the use of electricity as essential instead of purely secondary, and thus ranking their device with the many quack processes which have been thus dubbed.

After being pickled in the acid bath above mentioned the articles to be coated are transferred to a tank of lime-water to remove adhering acid, and then passed into one consisting of a solution of the chlorides of tin and zinc made by dissolving equal weights of the two metals in hydrochloric acid to the saturation of the latter, and thence to the bath of melted lead aforesaid.

The process as thus conducted seems to be efficient, the covering of even complicated surfaces being readily effected; the lead adheres to the underlying metal with considerable tenacity, a property which may be ascribed to the very careful and thorough cleansing the latter undergoes before immersion in the former. The precise chemical effect of the hydrofluoric acid in the first bath is far from clear; but it is reasonable to suppose that the zinc chloride and stannous chloride constituting the third, act, the one by removing any trace of oxide that may still adhere after the preliminary pickling, and the other by

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preserving the chemically clean iron from possible oxidation at a later stage. When once the adhesion of the lead to the iron has been secured, the softness and ductility of lead will allow considerable deformation of the underlying metal before fracture of the coating occurs. In this respect lead presents a great contrast to zinc, and might replace it for many purposes if it were not that, being electro-negative to iron, it tends to hasten the attack of the latter by most of the corrosive agencies to which the coated metal is exposed, under such conditions as permit both lead and iron to be in contact with an electrolyte. The preservation of the lead coating in its integrity would prevent corrosion of this character taking place; and considering the perfection of the adhesion of the lead to the iron the chance of removal by cracking or scaling is remote. On the other hand, the extreme softness of lead must cause it to be readily pierced and even stripped by chafing against any moderately hard substance; and from the moment when a portion of the iron has been laid bare, the process of corrosion will proceed with greater rapidity at the particular spot exposed than would have been the case had the metal been wholly unprotected. It is true that it may be found that the corrosion may be confined to the portion of the metal exposed, and be of less complete and injurious character than that which occurs in the case of ordinary tin plate. This is, however, an assumption that can only be proved or disproved by experiment. We insist somewhat strongly upon this point, inasmuch as should the objection we have indicated be overruled by actual trial, or provided for by some modification of the present method, the process will supply many of the needs of the electrical engineer. Among the applications which may be quoted are the coating of telegraph posts, the protection of iron and steel wire, and the formation of lead-lined tanks for electrolytic operations. The covering of wire is an application of special interest, on account of the absence of any tendency on the part of the lead coating to reduce the tensile strength in the manner peculiar to galvanising. A smaller but not uninteresting use to which lead coating may be put is the protection of staples, large numbers of which are at present galvanised; the act of driving in a galvanised iron staple is very liable to chip its coating, a result little to be feared when its covering is lead: indeed, lead-covered staples are said to endure the test of being opened out flat without damage to the coating or fracture of the iron itself. The method, as it stands, appears promising, and upon the tendency of partially stripped articles to suffer severe corrosion being avoided or mitigated, should find many useful applications.

ON THE DISCHARGE OF ELECTRICITY THROUGH EXHAUSTED TUBES WITHOUT ELECTRODES.*

BY J. J. THOMSON, M.A., F.R.S.

(Continued from page 15.)

Action of a Magnet on the Discharge.

The discharges which take place in these tubes and bulbs are produced by periodic currents, so that the discharges themselves are periodic, and the luminosity is produced by currents passing in opposite directions. As this is the case, it seemed possible that the uniformity of the luminosity seen in the discharge was due to the superposition of two stratified discharges in opposite directions, the places of maximum luminosity in the one fitting into those of minimum luminosity in the other. Since these discharges are in opposite directions, they will be pushed opposite ways when a magnetic force acts at right angles to them, the discharges in opposite directions can thus be separated by the application of a magnetic force and examined separately. In the experiment which was tried with this object, a square tube was used placed outside the primary, the tube at one or two places being blown out into a bulb so as to allow of the wider separation of the constituent discharges. When one of these bulbs was placed in a magnetic field where the force was at right angles to the discharge, the luminous discharge through the bulb was divided into two portions which were driven to opposite sides of the bulb; each of these portions was of uniform luminosity and exhibited no trace of striation. It was noticed, however, in making this experiment that the discharge seemed to have much greater difficulty in passing through the tube when the electro-magnet was on than when it was off. This observation was followed up by several other experiments, and it was found that the discharge is retarded in a most remarkable way by a magnetic force acting at right angles to the line of discharge. This effect is most strikingly shown when the discharge passes as a ring through a spherical bulb. If such a bulb is placed near a strong electro-magnet, it is easy to adjust the length of spark so that when the magnet is off a brilliant discharge passes through the bulb, while when the magnet is on no discharge at all can be detected. The action is very striking, and the explanation of it which seems to fit in best with the phenomena I have observed is that the discharge through the rarefied gas does not rise to its full intensity suddenly, but as it were feels its way. The gas first breaks down along the line where the electromotive intensity is a maximum, and a small discharge takes place along this line. This discharge produces a supply of dissociated molecules along which subsequent discharges can pass with greater ease. Thus under the action of these electric forces the gas is in a state of unstable equilibrium, since as soon as any small discharge passes through it the gas becomes electrically weaker and less able to resist subsequent discharges. When the gas is in a magnetic field, the magnetic force acting on the discharge produces a mechanical force which displaces the molecules taking part in the discharge from the line of maximum electric intensity, and thus subsequent discharges do not find it any easier to pass along this line in consequence of the passage of the previous one. There will not, therefore, be the same instability in this case as in the one where no magnetic force acted upon the gas. A confirmation of this view is, I think, afforded by the appearance presented by the discharge when the intensity of the magnetic field is reduced, so that the discharge just, but only just, passes when the magnetic field is on. In this case the discharge, instead of passing as a steady fixed ring, flickers about the tube in a very undecided way.

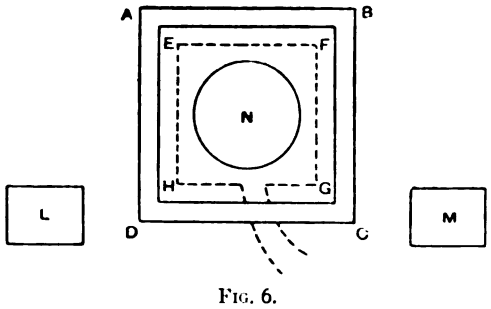

FIG. 6.

If the strength of the magnetic field is reduced still further, so that the discharge passes with some ease, the bright ring which, when no magnetic force is acting, is in one plane, is changed into a luminous band situated between two planes which intersect along a diameter of the bulb at right angles to the magnetic force. These planes are inclined at a considerable angle, one being above and the other below the plane of the undisturbed ring. This displacement of the ring by the magnetic force shows that it consists of currents circulating tangentially round the ring.

This action of a magnet on a discharge flowing at right angles to its lines of force is not, however, the only remarkable effect produced by a magnet on the discharge. When the lines of magnetic force are along the line of discharge, the action of the magnet is to facilitate the discharge and not to retard it as in the former case. The first indication of this was observed when the jars were connected, as in (*a*) in Fig. 1. The earth-connection being removed, in this case there is a glow from the glass into the bulb, due to the redistribution of the electricity induced on the glass by the primary when it is at a high potential before the spark passes. If the primary is connected to earth by a circuit with an air-break in it, the intensity of the glow may be altered at will by adjusting the length of the air-break; when the air-space is very small there is no glow; when it is long the glow is bright. The bulb in which the discharge was to take place was placed on a piece of ebonite over the pole of an electro-magnet, and the air-space in the earth-connection of the primary was adjusted so that when the magnet was off no glow was observed in the tube. When the magnet was on, however, a glow radiating in the direction of the lines of magnetic force was produced, which lasted as long as the magnet was on, and died away rapidly, but not instantaneously, when the magnet was taken off. In this case the discharge seems to be much easier along the lines of magnetic force.

The following experiment shows that this effect is not confined to the glow discharge, but is also operative when the discharge passes entirely through the gas. A square tube A B C D (Fig. 6) is placed outside the primary E F G H, the lower part of the discharge tube C D being situated between the poles L M of an electro-magnet. By altering the length of spark of the Wimshurst machine,

* Abstract from the *Phil. Mag.* October, 1891.

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the electromotive intensity acting on the secondary can be so adjusted that no discharge passes round the tube A B C D when the magnet is off, whilst a bright discharge occurs as long as the magnet is on. The two effects of the magnet on the discharge, viz., the stoppage of the discharge across the lines of magnetic force, and its acceleration along them, may be prettily illustrated by placing in this experiment an exhausted bulb N inside the primary; then the spark length can be adjusted so that when the magnet is off the discharge passes in the bulb and not in the square tube, while when the magnet is on the discharge passes in the square tube, and not in the bulb.

The experiments on the effect of the magnetic field on the discharge were tried with air, carbonic acid, and oxygen, but I could not detect any difference in the behaviour of the gases.

The explanation of the longitudinal effect of magnetic force seems more obscure than that of the transverse effect; it is possible, however, that both may be due to the same cause, for if the feeble discharge which we suppose precedes the main discharge branches away at all from the line of main discharge the action of the magnetic force when it is along the discharge will tend to bring these branches into the main line of discharge; and thus there will be a greater supply of dissociated molecules along the main line of discharge, and therefore an easier path for the subsequent discharges when the magnetic force is acting than when it is absent.

It is perhaps not necessary to assume that the mechanical action of the magnetic force is on a small discharge preceding the main one; the action of the magnetic force on the chain of polarised molecules which are formed before the discharge passes might produce an effect equivalent to that which we have supposed was produced on an actual discharge.

The chain of polarised molecules would be affected in the following way:—The magnetic field due to the electro-magnet consists of tubes of electrostatic induction moving about; these tubes, as well as the direction in which they are moving, are at right angles to the lines of magnetic force. The short tubes of electrostatic induction which join the atoms in the molecules of the gas will, under the influence of the electric forces, set themselves parallel to the direction of the electromotive intensity at each point.

Thus, when the magnetic force is at right angles to the line of discharge, tubes of electrostatic induction parallel to those in the molecules will be moving about in the field; and since parallel tubes exert attraction and repulsion on each other, the molecular tubes will be knocked about, and their efforts to form closed chains made much more difficult by the action of the magnet. On the other hand, when the lines of magnetic force are parallel to the discharge, the moving tubes are at right angles to those in the molecules, and will not disturb them in the attempt to form chains along the line of magnetic force, they will in fact assist them in doing so by preventing all attempts in directions across the lines of force.

Prof. G. F. Fitzgerald has suggested to me in conversation that this action of a magnet on the discharge might be the cause of the "streamers" which are observed in the aurora; the rare air being electrically weaker along the lines of magnetic force than at right angles to them will cause the discharge in the direction of those lines to be the brightest.

Discharge through Different Gases.

I have examined the discharge through air, carbonic acid, hydrogen, oxygen, coal gas, and acetylene. As I have already mentioned, at the highest pressures at which the discharge passes through air, the discharge is reddish, and gets brighter and whiter at lower pressures. If the discharge is examined through a spectroscope the lines in the spectrum coincide with those obtained by sparking through air in the ordinary way with a jar in the circuit. The relative brightness of the lines in the spectrum of the discharge without electrodes varies very much with the pressure of the gas and the length of spark in the jar circuit. With a long spark in this circuit, and the pressure such as to give a bright white discharge, the spectrum is very much like that of the ordinary jar-discharge in air. When, however, the pressure is so low that the discharge passes with difficulty, a few lines in the spectrum shine out very brightly, while others become faint, so faint indeed sometimes that if the air-spectrum were not thrown into the field of view of the spectroscope at the same time they might pass unnoticed. Three lines which are very persistent, the first a citron-green, the second a more refrangible green, and the third a blue, I am inclined to think must be due to mercury vapour from the pump.

I am indebted to Prof. Liveing for the loan of a very fine direct-vision spectroscope, and to him and Mr. Robinson, of the Cambridge Chemical Laboratory, for valuable advice in the attempts which I made to photograph the spectra of some phosphorescent glow mentioned below.

I should like to call attention to the advantages for spectroscopic purposes which attend this method of producing the discharge: it is easily done, either by an ordinary electrical machine or an induction coil. An intensely bright discharge is got, and there is no danger of complication arising from the spectrum of the gas getting mixed with that of the electrodes.

Discharge in Oxygen.

By far the most remarkable appearance is presented when the discharge passes through oxygen, for in this gas the bright discharge is succeeded by a phosphorescent glow which lasts for a considerable time; indeed, with a strong discharge it may remain visible for more than a minute. When the discharges succeed one another pretty rapidly, the phosphorescence is so strong that it hides the successive bright discharges, and the tube seems permanently full of a bright yellow fog. We can thus by the use of this gas convert the intermittent light given by the bright discharge into a continuous one.

Perhaps the most striking way of showing this phosphorescence is to use a long tube, about a metre long and 6 or 7 centimetres in diameter, with a bulb blown in the middle, the primary coil being twisted round this bulb. Then, when the sparks pass between the jars, a bright ring-discharge passed through the bulb, from which, as if shot out from the ring, the phosphorescent glow travels in both directions along the tube, moving slowly enough for its motion to be followed by the eye. It cannot, therefore, be produced by the direct action of the light from the spark on the gas in the tube, for if it were, the glow would travel with the velocity of light. It is necessary to mention this point, for the light from these discharges has great powers of producing phosphorescence.

The glow seems to consist of gas which has been in the path of the discharge, and whose molecules have been split up by it and projected from the line of discharge. This gas, which, when projected, is in a peculiar state, by a process of chemical combination gradually returns to its original condition, and it is while it is in this state of transition from its new condition to the old that it phosphoresces. If this is the case we should expect that the period of phosphorescence would be shortened by raising the temperature. On trying the experiment I found that this took place to a very marked extent. A discharge-bulb filled with oxygen at a low pressure was placed over a Bunsen burner; before the bulb got hot each bright discharge was succeeded by a bright after-glow, but as the bulb got hotter and hotter the glow became fainter and fainter, and at last ceased to be visible, though the bright ring was still produced at each discharge of the jar. When the Bunsen was taken away, and the bulb allowed to cool, the glow reappeared.

The spectrum of the afterglow is a continuous spectrum, in which I could not detect the superposition of any bright lines. The only gas besides oxygen in which I have been able to detect any after-glow is air, though in this case the range of pressure within which it is exhibited is exceedingly small; indeed, it is often by no means an easy matter to get a bulb filled with air into the state in which it shows the glow. The spectrum of the air-glow showed bright lines; I thought myself that I could see a very faint continuous spectrum as well. Some friends, however, who were kind enough to examine the spectrum, though they could see the bright lines clearly enough, were of opinion that there was nothing else visible. I endeavoured to photograph it, but without success, so that the existence of a continuous spectrum for this glow must be considered doubtful.

When the discharge passes through acetylene, the first two or three discharges are a bright apple-green, the subsequent ones, however, are white, and as the green discharge does not reappear we must conclude that the acetylene is decomposed by the discharge.

Phosphorescence produced by the Discharge.

The discharge without electrodes produces a very vivid phosphorescence in the glass of the vessel in which the discharge takes place; the phosphorescence is green when the bulb is made of German glass, blue when it is made of lead glass. Not only does the bulb itself phosphoresce, but a piece of ordinary glass tubing held outside the bulb and about a foot from it phosphoresces brightly: while uranium glass will phosphoresce at a distance of several feet from the discharge. Similar effects, but to a smaller extent, are produced by the ordinary spark between the poles of an electrical machine.

The vessel in which the discharge takes place may be regarded as the secondary of an induction coil, and the discharge in it shows similar properties to those exhibited by currents in a metallic secondary. Thus no discharge is produced unless there is a free way all round the tube; the discharge is stopped if the tube is fused up at any point. In order that the discharge may take place, it is necessary that the molecules of the gas shall be able to form a closed chain without the interposition of any non-conducting substance; indeed, the discharge seems to be hindered by the presence in such a chain of any second body, even though it may be a good conductor of electricity. Thus, when a tube such as that in Fig. 7 is used, which has a barometer tube attached to it, so that by raising or lowering the vessel into which the tube dips a mercury pellet may be introduced into the discharge circuit, the spark-length

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in the primary circuit may be so adjusted that a discharge passes when there is a clear way round the tube, but stops when a pellet of mercury is forced up so as to close the gangway. I noticed a similar effect in my experiments with a long vacuum tube described in the *Proceedings* of the Royal Society for January, 1891.

I had another discharge tube prepared, of which a section is shown in Fig. 8, *a*, in which a diaphragm (A B) of thin copper plate was placed across the tube; the diaphragm happened to catch at the bottom of the tube, so that it divided the latter rather unequally, and left a narrow passage round its edge. As much of the discharge as there was room for went round the edge of the plate; the remainder was not able to get through the copper, but formed a closed circuit by itself in the larger segment of the tube. In another tube, which is represented in section in Fig. 8, β, the copper diaphragm was attached to the walls of the tube by sealing-wax, so that there was no free way: in this case the discharge again refused to go through the copper, and split up into two separate discharges, as in the figure. When the tube was divided by copper diaphragms into six segments, as in Fig. 8, γ, no discharge at all would pass through. When the primary was slipped up the tube above the diaphragm a brilliant discharge was obtained. These four experiments all illustrate the difficulty which the electricity has in getting transferred from a gas to another conductor.

Fig. 7.

There is no discharge through the secondary, if it is of such a kind that, considering a closed curve drawn in it, the electromotive intensity as we travel along the curve tends to polarise the particles in one half of the chain in one direction, and in the other half in the opposite direction, the direction being reckoned relative to the direction we are travelling round the curve. Thus, for example, if we take a tube whose axis is bent back on itself, as in the figure, the electromotive intensity will tend to polarise the particles in one part of the chain in the direction of the arrow, and those in the other in the opposite direction; it is impossible to get a discharge through a tube of this kind.

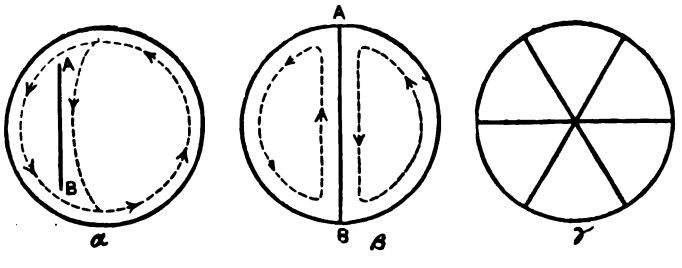

Fig. 8.

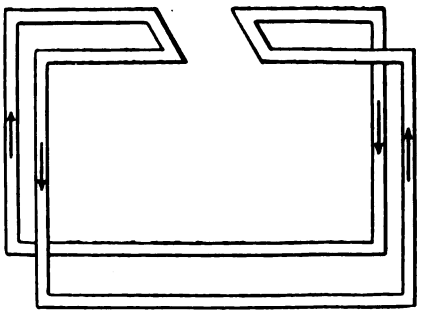

Fig. 9.

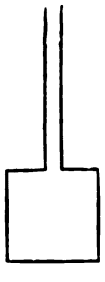

Fig. 10.

On the other hand, the molecules exhibit remarkable powers of making closed chains for themselves when not actually prevented by the action of the electromotive intensity. Thus the discharge will pass through a great length of tubing in the secondary, even if it is bent up as in Fig. 10, where the vertical piece in the upper part of the secondary is at right angles to the direction of the electric force, and where the molecules will receive no help in forming closed chains from the action of the external electromotive forces. I have succeeded in sending discharges through tubes of this kind 12ft. to 14ft. in length.

Screening Effects Due to the Currents in the Tubes.

One very noticeable feature of these discharges is the well-defined character of the ring, if the pressure is not too low. If a large bulb is used for the secondary with the primary just outside it, when the sparks pass between the jars a bright well-defined ring passes through the bulb near to the surface of the glass, the gas inside this ring being, as far as can be judged, quite free from any discharge. If now a bulb whose diameter is less than that of the luminous ring is inserted in the primary in place of the larger bulb, a bright ring will start in this, though at this distance from the primary there was no discharge in the larger bulb. Thus, when the large bulb was in the primary, the discharge through its outer portions screened the interior from electromotive forces to an extent sufficient to stop a discharge which would otherwise take place.

The screening action of these discharges is also shown by the following experiment. A, B, C, Fig. 11, is the section of a glass vessel shaped like a Bunsen's calorimeter; in the inner portion A, B, C of this vessel an exhausted tube is placed, while a pipe from the outer vessel leads to a mercury pump and enables us to alter the pressure at will. The primary coil, L, M, is wound round the outer tube. When the air in the outer tube is at atmospheric pressure, the discharge caused by the action of the primary passes in the tube E inserted in A B C; but when the pressure in the outer tube is reduced until a discharge passes through it, the discharge in the inner one stops; the discharge in the outer tube has thus shielded the inner tube from the action of the primary. If the exhaustion of the outer tube is carried so far that the discharge through it ceases, that in the inner tube begins again. It requires very high exhaustion to do this, and as on account of the joints it is unsafe to make the vessel very hot during the pumping, I have found it impossible to keep a vacuum good enough to show this effect for more than from half to three-quarters of an hour; in that time sufficient gas seems to have escaped from the sides of the vessel to make the pressure too high to show this effect, and it then takes from two to three hours' pumping to get the tube back again into its former state. An interesting feature of this experiment is that for a small range of pressure, just greater than that at which the discharge first appears in the outer tube, there is no discharge in either of the tubes; thus the action of the primary is screened off from the inner tube, though there is no luminosity visible in the outer one; this shows that a discharge equivalent in its effects to a current can exist in the gas without sufficient luminosity to be visible even in a darkened room. We shall have occasion to mention other cases in which the existence of a discharge non-luminous throughout the whole of its course is rendered evident in a similar way.

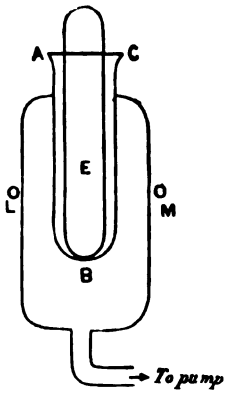

Fig. 11.

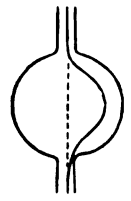

Fig. 12.

Another experiment by which the screening can be effectively shown is to place the primary coil inside a bell-jar which is connected with a mercury pump, the electrical connections with the primary being led through mercury joints. An exhausted bulb is placed inside the primary, the bulb being considerably smaller than the primary, so that there is an air-space between the two. Before the bell-jar is exhausted the discharge passes through the bulb, but when the bell-jar is exhausted sufficiently to allow of the discharge passing through the gas outside the bulb the discharge in the bulb ceases, and the only discharge is that outside. I have never been able to exhaust the bulb sufficiently well to get the discharge outside the bell-jar to cease, and that in the bulb to appear again, as in the preceding experiment. In this experiment, as in the preceding one, there was a range of pressure when neither the bulb nor the bell-jar was luminous, showing again the existence of currents in the gas which are not accompanied by any appreciable luminosity.

A curious bending in of the discharge which takes place in a square tube provided with a bulb can, I think, be explained by the principle of shielding. The discharge in the bulb does not, unless very long sparks are used, take as its course through the bulb the prolongation of the direction of the tube, but is bent in towards the primary. In Fig. 12 the dotted line represents the course the

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discharge would have taken if there had been no bulb, the continuous line the course actually taken. This bending-in can be explained by supposing the currents started near the primary to shield off from the outlying space the action of the primary, and thus make the electromotive intensity along the axis of the tube smaller than it would have been if no discharge had been possible between the axis and the primary circuit.

(To be continued.)

ON SOME DETAILS IN THE CONSTRUCTION OF MODERN LANCASHIRE BOILERS.*

BY SAMUEL BOSWELL, OF MANCHESTER.

The great advance in engineering, due to the use of higher steam pressure, has brought about numerous improvements in the design and construction of Lancashire boilers, which however in many points are still far from perfect. The subject will be dealt with under the general headings of material, construction, and testing.

Steel.—At the present time the most suitable material that can be used for the construction of Lancashire boilers is believed to be mild steel manufactured by the Siemens-Martin open-hearth process, which is preferred to that made on the Bessemer process because it is generally found to be more homogeneous and reliable.

Test Strips.—When the plates have been delivered to the boiler works, strips are sometimes cut off for testing purposes. Those taken from the manhole scrap generally give the best results, because any surface imperfection or lamination is least likely to be found in the centre of the plate; consequently, such tests are most favourable to the steel maker. Strips cut from plate ends are far more likely to expose defects, such as blisters, overlapping, deficient thickness, uneven surfaces, and hardening due to the chilling effect of throwing plates hot from the rolls down upon the cold plate-floor.

When plates are ordered for the best boilers, it is generally agreed that their tensile strength shall be not less than 26 tons per square inch and not more than 30 tons, while the elongation must not be less than 20 per cent. in a length of 10in., the test strips being usually 2in. wide. In the bending test, the strip should be bent cold to a radius $1\frac{1}{2}$ times its thickness, until its ends are parallel with each other; and in the chill or temper test to a radius equal to twice its thickness. With plates from the best works there is no difficulty in getting these results.

Sizes of Plates.—As regards width, 3ft. to 3ft. 6in. is found most reliable, and most convenient on account of the spacing of the mountings on the boiler crown. As to length, one plate to a ring is undoubtedly the best arrangement, because it allows all the longitudinal seams to be near the crown, and they are then always accessible, above water level, out of the way of corrosion, and clear of brickwork. But where there is not machinery suitable for handling such long plates, then two plates to a ring must be adopted, care being taken to keep the longitudinal seams clear of the seatings.

Form of Seam.—The butt joint with double butt-straps is without doubt the best and strongest, the plates can be bent to a true circle, and the rivets are in double shear. In bending the plates for lap joints, there is only a slight deviation from the true circle; but in thick plates this occasionally leads to some slight damage in closing the joints at the corners where they have been thinned.

Thinning of Corners.—In most of the best boiler-works the corners of the plates are thinned by planing them down; but this in the writer's opinion is not the correct thing to do, unless the plates are made to a special shape. No doubt it obviates local heating and consequent internal strains in the plate. The writer has tried several experiments to ascertain the effect of heating plates locally. In one case a piece of steel boiler-plate was bulged out of shape in the middle, made hot at the bulge, hammered back to its original form, and planed into seven strips, which were then tested, showing that the local heating did not appear to have influenced the strength or ductility of the plate in the slightest degree.

With butt joints the thin corners of plates are got rid of; and sometimes the same principle is carried even further, as shown by making the butt-strap ends to butt against the edge of the next plate. This certainly makes a neat finish, but it is not so reliable as when the strap ends are thinned and tucked under the edge of the next plate.

Edges of Plates.—These are invariably planed in all the best works. The edge should be planed to the angle most suitable for calking. When planed to the angle of 75deg., then after fullering, which really means calking with a tool equal in thickness to the plate, the angle or bevel of the plate should be 80deg.

Bending of Plates.—Care should be taken to see that the sweep of the plate is carried to the very extremity in the bending rolls, so as not to require the ends setting to the curve with hammers. The plate is often hurried through the rolls, and is even bent to the full sweep at one operation, which should never be allowed.

Drilling.—In order to hold the plates in position without a number of tack holes, inside and outside angle-rings are sometimes employed, with a number of set-screws in each, by which the plates are held in a circular form; but whether they are really drawn up metal to metal as tight as they should be is to the writer doubtful. His own idea of really good tight work is to drill first a number of small tack holes, say $\frac{5}{8}$in. diameter and about 3ft. apart along the longitudinal and the circular joints alike, and to drill the joint holes with $\frac{1}{8}$in. draw, so that when bolting up in readiness for the drilling machine a drift can be inserted and the plates drawn up and bolted metal to metal, thus insuring good work; the $\frac{5}{8}$in. holes can easily be drilled out finally to the proper size after the bolts have been taken out. No doubt the use of the drift may be objected to; but in the writer's opinion it is in many cases essentially necessary to use it if good work is required. In most boiler-works it is denied that any use is made of the drift; but where is there a works without it? and although no tool is more misused, yet, when properly used as above described, what tool will do so much good work? It is only in the hands of inferior workmen, and with inferior material, that the drift is said to be worse than useless; but it only exposes that which should not exist, and in this connection, therefore, it has an unmerited bad name.

After drilling, the plates should be taken asunder, and the holes cleared of the burr left by the drills. With a proper tool this is not a difficult task, but it is important that it should be done, and, in the writer's opinion, the holes should even be slightly countersunk round the outer edge in order further to strengthen the riveting, especially where the rivets are in tension. It is when the plates are taken asunder that it can be discovered whether or not they have been drawn tightly together, metal to metal. If they have been put together as already suggested no burr whatever will be seen between the plates, and no trace of slackness will be visible when they are again put together for riveting up.

Riveting.—The proper diameter of the rivets will be influenced by the thickness of plate through which they pass. In the pitch, not only strength but steam tightness must be considered; occasionally, therefore, the adoption of the strongest pitch is precluded on account of steam tightness, though the writer believes that wider and stronger pitches than at present used may be adopted without fear of leakage, particularly when steel rivets are employed, put in properly heated, and well closed into the holes. When rivets are thrown into the rivet furnace by the bagful, and then brought out by the shovelful, often thickly coated with oxide and slag, it is next to impossible to make good work. There seems no reason why the rivets should not be heated to a bright red heat, brought out singly, and each rivet passed through a fine spray of water, which would immediately chill any oxide or slag and cause it to shell off, without in any way affecting the rivet itself; and then a perfectly clean rivet would be put in a perfectly clean hole.

Too much care cannot be exercised in seeing that the riveting is well done, both at the machine and by hand. If the rivets are not well closed in the hole, the previous attention to their size and cleanliness will be so much time wasted. To close a rivet well in its hole, it must be neither too hot, nor too slack in the hole, or else it will bend before it will thicken; and then it is impossible to fill the hole, however powerful the machine may be. The compression which acts on the rivet should not come upon it too suddenly, nor be of too short duration; but should rather be slow, so as not to leave the closed rivet at too high a temperature. Perhaps the best means of judging good sound riveting is to stand by when it is being done, and to notice how long the rivet remains hot. When a clean rivet is well closed in tight, it will go black immediately, showing that the colder metal round the hole has come in direct contact with the rivet and has abstracted the heat from it; while a slack or dirty rivet badly closed will remain hot for a considerable time. This will be seen at once by watching a good riveting machine, and then watching a set of hand riveters, who seem to be giving more attention to the appearance of the rivet than to its usefulness and purpose. When engaged in piece-work on girders, it is astonishing how expeditiously the men can get through riveting, particularly when snap riveting. A few light blows from the hammer-panes are sufficient to form a rough head, and then half a dozen blows on the snap finish the rivet while it is still at a bright red heat; but the body of the rivet has never thickened in the hole, simply because the light blows have not had any effect except just at the point where the snap head is formed. What is wanted is that the rivet should be well forced into the hole, either by a steady pressure from a machine, or by a succession of good blows fair on the end of the rivet; and the size or shape of head thus formed are only a secondary consideration.

* Abstract of a Paper read before the Institution of Mechanical Engineers.

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Welding Flues.—For welding, long fires are used, with a pair of long parallel tuyeres, each containing a row of small blast-pipes, so that a full heat may be obtained along the whole length of the seam at once if required. When the rings of plates are welded under the steam hammer, three heats are often found sufficient to finish a ring of plate 3ft. 6in. wide. After welding, every ring should be carefully heated to a dull red along the weld, and be allowed to cool slowly, so as to anneal the portions that have been hammered, and thus set free any internal strains set up in the welding.

Circular Joints.—For the circular joints connecting the several rings of plates forming the flue, the ordinary lap-jointed seam is far too weak for the high pressures now in use, and may therefore at once be discarded. The seam most generally adopted is the Adamson flanged joint, but few even of the best makers seem to bestow as much care on it as was done by the originator himself. The radius of the flanging is generally less than desirable ; and the liner ring of soft iron is not always of the proper shape. Among the strengthening seams that are in use, there is one known as the Bowling or Bolton hoop, which perhaps for most purposes is a better seam than the Adamson flanged joint. The hoop should be put on hot, but should not be shrunk on the flue rings too tight, only tight enough to bring the hoop and rings together, metal to metal. If put on too tight, there is not only a difficulty in removing the hoop after drilling, but there is a probability that in the flue rings grooving or channelling will set in round the edges of the hoop, after the boiler has been at work a short time. Like the shell, the rings forming the flues should be put together blank, or with a few tack or guide holes, and then drilled in position, all burrs being removed before the insertion of the rivets ; and the same care should be exercised as in shell riveting.

Calking.—The next process is calking, which deserves more attention than is occasionally bestowed upon it. In some shops a number of youths are employed, into whose hands the calking tools are put without any instructions as to their proper use. When this mistake is made they are sure to do more harm than good, increasing the tendency to leakage, and rendering it almost impossible for another man to make the work good afterwards ; and they may niche the plate in such a manner as to lead to a serious fracture. All the tools used for calking should be ground to one uniform bevel, excepting only for special or corner work. When the plate edges are planed to the proper angle, it is easy for a practised eye to detect any irregular work. Calking never strengthens a seam, but often weakens or damages it ; and before long the writer believes that seams will be made tight without calking by hand tools, and that this will be accomplished either mechanically by abrasion, such as that produced by the friction of the edge of a revolving disc pressed hard against the edge of the plate, or else by the use of paint or cement.

End Plates.—The shell and flues having been calked are ready for being put together, and for the ends to be marked off. In building up a shell or flue, say 30ft. long, however carefully done there is always a tendency to creep, so as to be $\frac{1}{16}$in. or $\frac{1}{8}$in. longer or shorter than intended. This difference must, therefore, be made up in such a manner that the end plates shall be quite flat, without the slightest straining; for any strain existing in the boiler while at rest would certainly be increased when at work. Fortunately the best methods of connecting the end plates to the shell and flues are such as will accommodate any little difference there may be in length between shell and flues, the front end being secured to an outside angle-ring, while the back end is flanged and fitted inside the shell. The flues having been run in, the front end plate is bolted up first, the back ends being left quite free. The back end plate is next put in place, and its flange is forced into the shell until the plate itself is close up to the flue ends ; the holes in the flange are then marked with a centre punch, and the end so centred is taken down and drilled ; after which all will go together, and can be bolted up and riveted without producing the slightest pull on any part, every portion being left in a state of rest.

As the end plates are flat, they require more care than any other part, in order to ensure that they shall be of the proper thickness and efficiently stayed without rendering them too rigid. As it is, however, if the end plates of a boiler are not properly designed, their strength rapidly becomes weakness. They must be sufficiently pliant to yield to the varying expansion and contraction, without failing under steam pressure; and practice has shown that, in well-constructed Lancashire boilers, end plates $\frac{1}{2}$in. to $\frac{7}{8}$in. thick, when properly secured to the shell and flues and properly stayed, may be used with safety for pressures up to 100lb. per square inch.

Gusset Stays.—In regard to the position and mode of attachment of gussets, it will readily be admitted that the most uniform distribution of the load will be the best. The attachments to the shell will therefore be on the first and second rings of the shell alternately, with gusset plates between double angles, so that the rivets will be subject to a double shearing strain ; and the angles sh uld be arranged sufficiently close together to have a fair grip on the gusset plate. As boilers of different diameters have the gussets radiating from different points, the angle of attachment will vary accordingly ; and therefore the general custom is to knock the angle to a suitable bevel : a piece of work which is rarely satisfactory, but as it is in a position somewhat inaccessible it is often allowed to pass, while if it were more visible it would certainly be condemned. It is of course advisable to have all gusset angles made of mild steel, so as not to be troubled with the reedy fractures so often found in angle iron and iron bars of similar section.

Longitudinal Bolt Stays. When the end plates are well supported by gussets, longitudinal bolt stays are considered by the writer to be unnecessary. When the required support can be given to each end plate independently of the other, as it is by gussets, it is not advisable to tie the two end plates together by rigid tension bars, such as the longitudinal stays often are. If the shell were weak in a longitudinal direction, then the support afforded by longitudinal bolt stays would be useful ; but seeing that there is already an excess of strength in the shell longitudinally, the rigid bolts are worse than useless, inasmuch as they interfere not only with the accessibility of the interior, but also with the application of such fittings as the low-water safety-valve, and, what is most important, with the expansion and contraction of the flues and shell. Whenever these bolt stays are applied as a secondary support, they should be left slack enough to allow of the boiler attaining its maximum length by expansion before they are tight ; and a good rule of thumb is to allow them to sag downwards, say 4in., when cold. A loose hanger should be added to carry the weight of the stays, so that in case of transit the vibration shall not be likely to break them, as has many times been the case. Where there are no gussets, then longitudinal stays serve quite another purpose ; and in many cases where they have been used in cylindrical boilers externally fired they have served a good purpose, when seam rents have occurred, in keeping the parts together ; and, although they have not prevented an explosion, they have reduced the extent of damage to narrower limits.

Mounting Blocks or Stand-pipes.—These are now generally made of wrought-iron or mild steel, and by two different processes. In some cases they are made of angles of special section ; in others they are made of ordinary plate cut to shape, flanged at both ends, and the top flange strengthened by having a plate or washer welded to it. The latter process appears preferable to the use of angles, because with angles it is not an easy matter to bring to shape a heavy section of material, such as is required, without the risk of making an unsound weld. For size of opening it is found that 1ft. 4$\frac{1}{2}$in. diameter is sufficiently large to admit any ordinary man to pass through, or any of the internal fittings used in the boiler. The manhole cover should also be of wrought-iron or mild steel, of not too heavy a section, say 1in. thick, cambered 2in., and secured by sixteen bolts of 1in. diameter. Such a manhole and cover have been tested by water pressure to 1,000lb. per square inch, without the slightest sign of distress. A light cover is more easily handled and jointed than a heavier one ; and with a good number of bolts, the failure of any bolt, or the oversight of one not being screwed up tight is of less importance than if only a dozen bolts were used of 1$\frac{1}{2}$in. diameter, as is often the case at present.

Hydraulic Testing.—The final stage through which the boiler has to pass before leaving the maker's works is perhaps the most important, though not always so regarded. It has often been argued that the hydraulic test is of little use ; in this view, however, the writer does not entirely agree, for although the Lancashire boiler is of such a form that the strength of every part may be ascertained with a fair amount of accuracy, still the hydraulic test has before now revealed defects which would otherwise have escaped notice. For instance, the gussets may to outward appearance be good and firm, and yet may be fractured through the line of rivets ; and the same might be the case with the bottom flange of the manhole. Many parts may be overlooked by the workman ; and even the foreman cannot be expected to see every little detail. For testing a boiler the writer's recommendation is to proceed as follows : after making all joints good, connect a small steam-pipe, and turn steam into the boiler until there is a pressure of 3lb. or 4lb. per square inch, when any leakages at places not soundly calked or at loose rivets can readily be found. These can then be chalked, and the steam blown out ; the boiler being warm will soon get dry for the men to calk the leaky parts, which when dry are made good with about half the trouble entailed in calking a wet seam ; in fact, it is often impossible to calk a joint tight with a layer of water between the plates. After calking the visible leakages, every fitting intended to be used when in working trim should be placed in position, the boiler filled with cold water, and tested by slowly increasing the pressure until the working pressure is reached, when a general survey should be made of all parts of the shell and the inside of the flues ; any leakages should be marked, the pressure released, and all weeps calked. Then should follow the final test, which

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may be arranged either with the fittings in position or with blank flanges on the stand-pipes; and the required pressure should be provided for by properly loading the safety-valves.

Here it has to be decided what is the proper test-pressure to apply. Testing the boiler to ascertain its fullest strength would mean testing it to destruction; and even before this extreme was reached the boiler would be seriously injured. There is, therefore, what seems a great difference of opinion among engineers as to the proper limit of test pressure, which has been variously given at from 1½ times to twice the working pressure; but a closer consideration goes to show that there is not a great difference after all. For those who go in for a high test-pressure go in also for a high factor of safety; and those who advise a moderate test-pressure require only a moderate factor. For instance, a test of double the working pressure with a factor of 6 is about equivalent to a test of 1½ times the working pressure with a factor of 4½; in each case the test-pressure amounts to one-third of the assumed bursting or collapsing pressure, and is a test that may safely be applied to most materials in engineering. The safest plan, therefore, appears to be to arrive at the bursting and collapsing pressures by careful calculation, and then to adopt a test-pressure accordingly.

For the final test the boiler should be again filled with water, and all parts carefully gauged when at rest. The flues should be gauged both horizontally and vertically; and a good way of doing this is to fix light battens across, the lighter the better, just tight enough to hold themselves in position at right angles to each other; when under test, any deviation from the original form will at once show itself by bending one batten and allowing the other to fall out; the amount of deflection can then be easily measured. The flat irregular surfaces of the end plates, however, are the most important, and should be carefully lined off, and light strings stretched tight across at say one inch distance from the plate; then, by inserting a paper gauge or wedge between the string and the end plate, the slightest trace of yielding can be discovered, measured, and recorded. After seeing that all is in readiness, the pressure may be applied up to the working limit, at which all parts should be carefully gauged and noted. Should there be no yielding of importance, then the pressure may be increased up to the test limit by gradual increments of 10 lbs. or 15 lbs, a sharp watch being kept on all sides at each increment. When the ultimate limit is reached, a strict examination should be made of all parts, and accurate gaugings taken; these will generally occupy about half-an-hour, during which time the pump should not be used, in order that any fall of pressure may then be seen. If the pressure has been maintained within one or two pounds during this time, it may then be released, and gaugings again taken, and compared with the original gaugings taken before the pressure was applied, when any permanent set or deflection will be at once apparent. If so far satisfactory, the water may be run out; and a careful examination of all internal parts should be made, particularly of the gussets, and of all rivets that are in tension, as these do occasionally go wrong, especially in inferior work or with indifferent material.

If all parts have been found to stand the testing satisfactorily, the boiler may be pronounced quite equal to the requirements. If when forwarded to its destination it should happen to have been subjected to unusually rough treatment during transit, it is a good plan to have it placed over its seating ready for building in, and then to fill it with cold water, when any of the seams that may have been shaken can be re-calked; but there is no necessity for any further test.

HIGH AND LOW POWER INCANDESCENT LAMPS.*

In *The Electrician* of September 25 there is a comparison between the ordinary incandescent lamp of 10 or 16 candles and lamps of 500 or 1,000 candles. This comparison sets forth the great advantage of using the latter. The question being a very interesting one in practice, we propose, without wishing in the slightest degree to call the author of the article to account, to examine the figures he quotes. We give his figures in the following table:—

Cost of 500 Candles for 1,000 Hours.

Type of lamp employed.	Energy expended at ·0725fr. for 100 watts.	Price of lamps.	Total expenditure in francs.
32 16-c.p. lamps, taking 4 watts per candle, and costing 4·7fr. each	1,470	150·4	1,620·49
1 500-c.p. lamp, taking 2 watts per candle, and costing 28fr.	735	28	762
		Difference,	858·49

* From *La Lumière Électrique*, October 31, 1891.

Presented in this manner, the comparison between the two types of lamp, the 16-candle lamp on the one hand and the 500-candle lamp on the other, relates to two points—the cost of the lamps, and the energy expended per unit of light. The price of the 16-c.p. lamp is set down at 4fr. 70 centimes. This very high figure is perhaps correct for England, but in any case it is only temporary, and in all other European countries the price is now under 2fr. The energy expended in the lamp is put down at 4 watts per candle for the 16-candle lamps, and at 2 watts for those of 500 candles. Here also we think there must be a gross error.*

One can make 2 watt 500-candle lamps as one can 2 watt 16-candle lamps; but either the life of these lamps will be at the most 50 to 80 hours, or at the end of a short time the amount of light they emit will have greatly diminished. Tests which we have carried out on lamps of 500 and 1,000 c.p., relate to a small number of lamps; but we have ascertained that when worked at 2 watts their illuminating power decreases by at least 30 per cent. after a 20 hours' run. After this fall the lamp runs at 3 or 4 watts per candle, and lasts, like its congeners of the same type, 800 or 1,000 hours. In fact, from the point of view of cost the only difference lies in the purchase price, which will be for an illumination of 500 candles for 1,000 hours—

(i.) Using 32 16-c.p. lamps, at 2fr. each	64fr.
(ii.) Using one 500-c.p. lamp, costing 28fr.	28fr.
Difference	36fr.

It now remains to attack the question from another point of view, which is, the useful effect produced by the two types of lamp. Now it is incontestable that everywhere where the glow lamp is preferred to the arc lamp there is good reason to multiply the sources of light, as much for the artistic effect as for the proper utilisation of the light. For instance, it is certain that for the lighting of an office the illumination given by 32 16-c.p. lamps might be satisfactory, while that produced by a 500-c.p. lamp would be defective.

To resume, while we think that one of these types may be preferable to the other in special cases, yet, generally speaking, from the point of view of economy, having regard to the light utilised, the advantage rests with the lamps of low illuminating power.

LEGAL INTELLIGENCE.

The Cadogan Electric Light Company.

On Saturday last there were two petitions before Mr. Justice Kekewich for winding up the Cadogan Electric Light Company. The first was presented by Mr. H. Lowenfeld, who asked for a winding-up order under the supervision of the Court; and the other was presented by Mr. E. E. Johnson, who asked for a compulsory winding-up order.

Mr. WARMINGTON, Q.C., in supporting the first petition, said his case was that, notwithstanding the voluntary liquidation which was commenced in February, the Company had been going on the same as before; and having read the liquidator's affidavit, his statement was—and the liquidator did not appear to contest it—that since the liquidation some creditors had been paid and not others, and he asked for an order because, he said, the liquidator had no right to prefer one creditor to another, but should pay all creditors equally. The learned counsel referred at considerable length to affidavits which had been filed by the liquidator and others, with a view of showing that it was necessary that an order should be made with a view to protecting the interests of creditors and others.

Mr. V. SMITH supported the second petition, asking for a compulsory winding up, contending that this was not a case which could be properly met by a supervision order.

Mr. WAGGETT, on behalf of the liquidator, said that with regard to the supervision order which was asked for, he could not, on behalf of the voluntary liquidator, say that he would object to be supervised if his Lordship thought that it was necessary; but he contended that no case whatever had been made out for a supervision order. He opposed most strenuously the making of a compulsory order, and affirmed that the petition asking for such an order had been wrongly presented.

Mr. JUSTICE KEKEWICH said that the case was not one in which there was any suggestion of fraud or matter of that kind requiring that the case should be placed in the hands of the Official Receiver. All that was needed was the protection of creditors. It was intended to hand over this Company's assets and business to a new company already formed, and in the carrying out of a transaction of that kind difficulties occurred in a

* It may be as well to state at once that the prices given were the current retail ones as per manufacturers' lists, and the same is true as regards the figures relating to watts per candle. Assuming equal veracity on either side, the object of the note criticised was to ascertain what life the more efficient higher candle-power lamp must have, taking into consideration the current price per B. T. U. supplied, in order not to cost more than its small competitor, which has an average life of 1,000 hours. The conclusions arrived at were somewhat surprising, and in many instances would undoubtedly have a practical bearing.—ED. *E.*

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compulsory winding up which were not encountered in a voluntary liquidation. On the other hand, the case appeared to be one in which the rights of creditors might be prejudiced by a voluntary winding up if the liquidator spent the assets in carrying on the business and making fresh installations which would have to be paid for in ready money. His Lordship therefore made the usual supervision order on the first petition, and made no order on the second petition.

Latimer Clark, Muirhead and Co., v. Francis.

In the Queen's Bench Division of the High Court of Justice on Friday last week the case of Latimer Clark, Muirhead and Co. (Limited), v. Francis, came before Mr. Justice Grantham, sitting without a jury. This was an action brought by the plaintiffs, electrical engineers, against Colonel George Francis, in reference to the sub division of founders' shares in the St. James's and Pall Mall Electric Lighting Company.

Mr. Lawson Walton, Q.C., and Mr. Gurdon appeared for the plaintiffs, while Mr. Whitehouse represented the defendant.

Mr. GURDON, in opening the case for the plaintiffs, said his clients and the defendant were joint founders of the St. James's and Pall Mall Electric Lighting Company, which was incorporated on the 2nd of March, 1888, and which was doing exceedingly well. By an agreement dated April, 1888, and scheduled in the Articles of Association between the Company and the founders, it was provided that the capital should be £100.000, divided into £19.980 ordinary shares of £5 each, and 100 founders' shares of £1 each. The founders guaranteed that 5.000 ordinary shares should be taken up by responsible persons by the 13th of April, 1888. For that the founders were to have allotted to them or their nominees 100 founders' shares in the Company, and the founders agreed to make over 25 founders' shares, or one share to every person who applied for 200 ordinary shares out of the first 5,000 allotted. The 5,000 shares were taken up or placed in due time, and the parties became entitled to the founders' shares. On the morning of July 13th the defendant appeared at the plaintiffs' offices, and produced a list of the persons to whom he proposed to have the shares allotted, which was objected to.

His LORDSHIP said he understood that the shares were to be allotted as the founders respectively desired.

Mr. GURDON remarked that they were to be allotted as the plaintiffs and defendant desired. By the defendant's list more than 20 went to his nominees. The plaintiffs refused to sign it. The defendant said it must be signed that day for Somerset House, and that if the plaintiffs signed it he would afterwards adjust the shares and put them right. That was the basis of the claim.

His LORDSHIP: You say the defendant refused to rectify it?

Mr. GURDON: Yes.

Mr. WHITEHOUSE said the defendant's case that the shares were allotted by the Company with the full knowledge of the plaintiffs, and that everybody on the list was entitled to founders' shares, and it was assented to by the plaintiffs at the time.

His LORDSHIP inquired whether the learned counsel's contention was that the list represented the agreement between the parties, and was signed by the plaintiffs without any reservation of any kind.

Mr. WHITEHOUSE applied in the affirmative.

Mr. GURDON, resuming, explained that there was a counter claim with respect to the disposition of the 25 founders' shares in question and some preliminary expenses.

Mr. WHITEHOUSE said the St. James's Company was now practically under the domination of Mr. Latimer Clark and his friends. Colonel Francis, who was a Director, had been voted out by the plaintiffs' contingent.

Mr. GURDON said he denied the accuracy of that statement.

Mr. WHITEHOUSE said the list was signed and agreed at the time. Colonel Francis afterwards called on Mr. Latimer Clark because he had told him that his partner was dissatisfied. Then Colonel Francis said if anyone else should turn up who was entitled to a founders' share they would have to give him one. No one else had turned up, and the defendant was, therefore, under no liability.

His LORDSHIP said there was a letter which indicated that a readjustment was contemplated. It might be that the defendant did not mean anything of the kind.

The plaintiffs then called evidence with the object of showing that a readjustment of the founders' shares was necessary.

At the conclusion of the evidence his LORDSHIP held that no cause of action had been proved, and entered judgment for the defendant, with costs.

Mr. WHITEHOUSE said he would withdraw the counterclaim without prejudice to any further proceedings that might be necessary hereafter.

Uniacke v. Scott—Scott v. Uniacke.

On Thursday last week the above actions came before Mr. Justice Romer in the Chancery Division of the High Court of Justice.

Mrs. Mary Augusta Uniacke, the plaintiff, was a widow, and on the 19th of December, 1889, she, her son, F. W. P. Uniacke, and the defendant, Mr. Ronald Augustus Scott, of Acton-hill, an electrical engineer, executed in duplicate a deed by which F. W. P. Uniacke was apprenticed to the defendant for three years, from the 25th of December, 1889, agreeing to serve and not unlawfully absent himself, &c. By the same deed the defendant, in consideration of a premium of £150, agreed to receive Uniacke as an outdoor apprentice in the art of an electrical engineer, providing the apprentice should "serve his master faithfully and well, and in accordance with the rules and regulations of this establishment," and to pay him 7s. 6d. per week during the first year, 10s. per week during the second year, and 15s. per week during the third year. The plaintiff alleged that the defendant had committed various breaches of the agreements on his part contained in the deed, and in particular, *inter alia* (1) that he had not at any time properly taught or instructed F. W. P. Uniacke, or caused him to be properly taught or instructed, in the art or business of an electrical engineer: (2) that the defendant in September, 1890, without due cause, suspended F. W. P. Uniacke from attending, and refused to allow him to attend at the workshops and places of business of the defendant for one month: (3) that the defendant had discharged F. W. P. Uniacke. The plaintiff accordingly claimed a return of the premium, or, in the alternative, damages. The defendant denied that he had discharged the plaintiff or been faithfully served by him: and alleged that the suspension was in accordance with the rules and regulations exhibited in conspicuous parts on the works; that the apprentice had repeatedly and without leave absented himself from the workshops, and when there he had been very negligent. The defendant also alleged that the plaintiff had admitted that her son's heart was not in the work, and that both he and his mother were anxious that he should be discharged from his apprenticeship, and, without alleging any breach on the defendant's part, had requested the defendant to cancel the indenture. The defendant also denied any breaches on his part of his agreement to instruct, and counterclaimed, in respect of alleged breaches by the apprentice, for the sum of £50 as damages. The effect of the evidence is sufficiently stated in the judgment of his Lordship. The letter of October 27th referred to in the judgment was as follows:—

"Dear Sir: As you have known for some time now that I do not care for electrical engineering, I am writing to you to beg you to cancel my indentures. I have no fault to find with the works, but it was a mistake on my part ever to have tried electrical engineering. I trust that under the circumstances you will consent to return a reasonable portion of my premium.—I remain truly yours, FRANCIS UNIACKE."

Mr. Neville, Q.C., and Mr. J. W. Baines were for the plaintiff; and Mr. Haldane, Q.C., and Mr. H. Terrell were for the defendant.

Mr. JUSTICE ROMER, in giving judgment for the plaintiff, said the defendant's business was somewhat peculiar. He had very few, apparently only seven or eight, workmen, properly so called, and a great number of pupils and apprentices. There were about 65 apprentices now, and at the date of the apprenticeship deed there were about 40. But his Lordship was not concerned with the question whether the defendant had taken too many pupils. It might be that he, nevertheless, did his duty to this particular pupil, and, even if he had not too many pupils, he might, nevertheless, have neglected his duty to this one. But the great number of pupils probably accounted for the neglect shown here. As to the first breach of duty alleged, his Lordship had to consider whether the defendant did commit a breach by not teaching and instructing the plaintiff's son. His Lordship had heard the evidence, and was very unfavourably impressed by the evidence of the defendant and his witnesses. The plaintiff's son, whatever little failings he might have, appeared to be a truthful young man"; and his evidence, where there was a discrepancy, was to be preferred to that on the other side. His Lordship was convinced that the son was not taught, or attempted to be taught, to any substantial extent, the art of an electrical engineer. He was only employed in handy work, which saved the whole or part of a workman's wages. For nine months he had been kept at two sorts of work only, viz., filing and fitting brass rods, and attending to a machine for making brass screws. No real instruction in electrical engineering had been given at all. One of the defendant's witnesses said Mr. Uniacke had been put on a lathe, but the apprentice denied this, and probably the defendant's witness had been misled by the fact of there being so many pupils. His Lordship quite agreed that, in teaching the art of electrical engineering, it might be very useful that a pupil should know something of the elements of the machinery and the articles used in the business; but that might be carried too far. There must be a limit to keeping the pupil to the elements of the business. The defendant was not justified in keeping the plaintiff's son for nine months at the mechanical work referred to. The son appeared to have been taught nothing. The defendant appeared to have left the business to his manager, and the manager to the foreman, and the foreman seemed to have looked on the pupil only as a person employed to do mechanical work. His Lordship held on the facts that the defendant had wholly neglected his duty, and was not surprised that the apprentice had disliked the work and been inattentive. He had been somewhat inattentive—principally by his absences, some of which had been caused by illness. But the inattention on his part had been grossly exaggerated. The defendant could not complain of this, having regard to his own neglect. No conduct of the plaintiff's son justified the defendant in his breaches of the apprenticeship deed. It was suggested by the defendant's witnesses that the plaintiff's son could not be taught this business, but, without attributing to him extraordinary ability, his Lordship was satisfied of his general intelligence. Under these circumstances the plaintiff's son became dissatisfied, and it was not surprising that his mother thought he had no heart for the business, and tried to get the deed cancelled, and obtain a return of part of the premium. After she had gone to India, the son's salary was reduced by the foreman, for some inattention, by 25 per cent. That was an ample punishment; but, on the son, complaining to the defendant, and merely because of such complaint, the defendant, not contenting himself with confirming what the foreman had done, suspended the son for a whole month, such suspension meaning that the son was not allowed to come to the works or receive any salary or instruction. That decision was unjustifiable. The defendant sought to justify it by referring to his rules and regulations; they were not brought to the attention of the plaintiff's son, if they were in existence at the date of the deed, or for some months afterwards. But the deed meant the rules and regulations for the time being, and the defendant might make reasonable rules and regulations. Nevertheless, a rule that for neglect an apprentice might be suspended for three months was unreasonable. At any rate suspension for a month in this case was un-

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reasonable, and could not be relied on by the defendant. Under the circumstances the defendant had done what amounted to grave breaches entitling the plaintiff to sue for damages, on the double ground of the entire neglect of the defendant in doing his duty to the plaintiff's son, and his breach of duty by refusing to instruct him. The breaches were so grave that it would be unreasonable to suppose that the plaintiff was bound to send her son back for the remainder of the term, and it would be absurd to say that she was still bound to treat the deed as not having been broken and practically put an end to by the defendant. His Lordship was also dissatisfied with the defendant's conduct in another matter. There was a complaint on the 24th of October of his neglect to teach the art of electrical engineering. The defendant, finding he was complained of for neglect of duty, suggested to the plaintiff's son that he should write the defendant a letter saying that he had no complaint to make of the defendant's works, and represented to him, or induced him to believe, that on such a letter being written a portion of the premium would be returned. The plaintiff's son accordingly wrote the letter of October 27th, and the defendant had admitted that when he suggested this letter he had no intention to return any part of the premium. His Lordship considered this a mere trick to get an acknowledgment that the apprentice had no fault to find with the works and so defeat any claim for neglect of duty on the defendant's part. His Lordship was surprised that the son wrote the letter, or that such letter was not stopped by the solicitor who was consulted by him; but that letter would not avail the defendant in this Court, which could still look at the true facts. His Lordship was satisfied that there had been a total neglect of the defendant's duty. When the plaintiff returned from India she found that her son was no longer at the works of the defendant, who had acceded to her son's request that until his mother returned he should not be obliged to attend the works at all. The mother was justified in bringing the action, and was not obliged further to treat the deed as compelling her to send her son to work. The plaintiff was entitled, not to a return of premium, but to damages, which his Lordship assessed at £120. The defendant must also pay the costs of the action, and his counter claim would be dismissed with costs.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October* 31, 1891.

Pittsburg Convention of the American Street Railway Association.—The Convention of the American Street Railway Association was a very notable gathering. In point of interest and enthusiasm it compared favourably with the Montreal Convention of the National Electric Light Association. Of the two the Street Railway Association is the more numerous and compact, and not only draws around it a large number of adherents, but tempts electrical manufacturers into making displays of no ordinary character. At Pittsburg, however, there was unfortunately no easily available hall suited for an electrical exhibition, and consequently the displays of the various companies were scattered around in a way that made it exceedingly difficult to form a good general idea as to what was really in place. A large barge moored in the river close to the Mornongahela House—the headquarters of the Convention—offered a habitation to a number of fine exhibits; but aside from this they were scattered promiscuously in the corridors and parlours of the hotel, and elsewhere in the vicinity. It is unnecessary to state that the Convention was of a very characteristically electrical character; all but two of the Papers were exclusively electrical. Of unusual interest were the Papers of Mr. G. W. Mansfield and Mr. O. T. Crosby, of the Thomson-Houston Company. The former gentleman gave an address on the various methods of supply that have been proposed in electric railroading. He is, like most electricians, an ardent advocate of the trolley system, not so much from any attributes of ideal perfection as from its intensely practical and workable characteristics. The conduit was in his opinion impracticable, at least under the conditions of climate with which American electricians have to contend; and any and all systems of rail supply he believed to be equally objectionable, unless in very peculiar situations. Mr. Crosby's Paper was a protest against the lack of standards both of rating and size, and in the nomenclature in the electrical railway business. Motors, he said, were usually rated by their alleged E.H.P., but this was indeed a most uncertain quantity, for the reason that the temptation was constantly before the manufacturers of electrical apparatus to rate their machines as high as possible, at their maximum rather than at their best available output. As a remedy he advocated classifying motors by the three factors of horizontal effort, speed, and efficiency. For example, he would describe a motor that gave 500 pounds horizontal effort and 60 per cent. efficiency at 10 miles an hour as a $500 \times 10 \times 60$ motor. This is unquestionably an improvement over the usual method of rating, but would create a constant temptation to exaggerate motor efficiency, which is well known to be low, sixty per cent., as noted by Mr. Crosby above, not being far from the correct figure generally. Further, the speaker advocated making all parts of electrical car equipment of a standard gauge, so that any motor could be fitted to any truck, and any trolley pole to a standard base. As regards nomenclature, he called attention to the wide variations between the practice of different companies, and the frequency with which they called the same article by different names. His suggestions in this line are well worth being followed. There is a tendency to the formation of a local electrical vernacular in every large manufactory. For example, the Brush Company has to shoulder the responsibility of the introduction of that very expressive term "nigger" into the electrical vocabulary, meaning thereby a short circuit burning and blacking field coils or cores. In a similar way the Westinghouse Company must be charged with the introduction of that very objectionable phrase "leakage current" to designate the slight current that flows through the primary of the transformer when the secondary is open. The Westinghouse Company threw open its great Pittsburgh factory, and it was visited by scores of delegates. No electrical company in the United States does more elegant and finished mechanical work than the Westinghouse; and the beautiful workmanship of their dynamos, motors, and subsidiary apparatus, won the universal commendation of every one who went through the factory. One of their most interesting exhibits was a gigantic multipolar generator in process of construction, intended to develope 500 E.H.P.; another smaller machine of a similar kind was shown running with a load, and its operation was perfectly smooth, noiseless, and sparkless when the load varied from nothing to 400 amperes at a single jump. In their factory, too, were shown the three types of Westinghouse motor truck—double reduction, single reduction, and gearless—arranged with Prony brakes, to exhibit their relative performances. A Westinghouse car, fitted with gearless trucks and gaily decked with banners, was one of the features of the Convention. The Short Electric Railway Company also had a gearless car on the road, and so confident were they of its good performance that they placed an ammeter and voltmeter upon it, and invited all who cared to do so to ride upon the car and measure for themselves the amount of power required. The result was, on the whole, decidedly satisfactory; for while the motors did not show a high efficiency they performed admirably, running cold and sparkless, handling the heavily loaded car with perfect ease on grades as high as five per cent. A number of test runs were made with this car, but the result of them has not yet been made public, although appearances seem to indicate that the power required was but little greater than that needed for the double or single reduction motors, the ratio being about three to two. It is proper to mention, however, that the Short Company was compelled to run—owing to other vehicles in the street—at a speed considerably below that for which it was designed. The Westinghouse car was put at even a greater disadvantage in this respect, as it was intended for a normal speed of 150 revolutions per minute instead of 100, as in the case of the Short; to this must be ascribed the fact that the Westinghouse Company made no car tests, and, indeed, it is reported to have peremptorily refused to allow them to be made, a somewhat unwise proceeding, even if apparently justified by commercial reasons.

The Edison Company exhibited a new single reduction motor. This machine shows a marked improvement over the original form, the design having been decidedly improved in the last four months.

The Thomson-Houston Company, in addition to other exhibits, showed the new iron-clad single reduction motor, of which I wrote you some few weeks since. They are now making these machines in considerable numbers, and its success is very gratifying. This motor is about the only one of the new crop of single reduction machines that shows any

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striking originality of design, and the variations introduced in it are probably of more fanciful than real advantage.

Nothing was seen at the Convention either of Mr. Edison, who was reported to have promised to be present, or of his new plans for electrical traction I have mentioned previously. To simmer down the whole matter, he proposes to use a voltage of about 20 with the rails properly bonded together as conductors, and is of necessity compelled to cut up the line into comparatively short unit lengths to be fed by motor generators. The requisite amperage demanded by this scheme is something appalling even to the imagination, and the scheme is generally condemned by experts as ingenious but impracticable. The impression seems to be prevalent that Mr. Edison in a frolicsome mood has been romancing for the benefit of an over-credulous reporter. As regards his high-speed proposition, no one seems to know whether he seriously intends working out that line of work or not, although the Edison Company is known to be contemplating the problem of a high speed road in the West. Whatever may come of it, Edison is assuredly somewhat behind the times in announcing it as anything in the least degree remarkable, in view of the experiments made by Mr. O. T. Crosby several years ago, and the plan proposed for an electric road between Budapest and Vienna. Perhaps here, too, the great inventor was amusing himself at the expense of the reporter.

Mr. A. E. Kennelly on Magnetic Reluctance.—At the last meeting of the American Institute of Electrical Engineers, on Tuesday evening last, Mr. A. E. Kennelly read a very interesting and suggestive paper on Magnetic Reluctance, transforming the curves of magnetisation given by various authors so as to show more distinctly the characteristics of this particular quantity. Like all Mr. Kennelly's work it was clear, thoughtful, and entertaining.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *November* 4, 1891.

The work in connection with the large central station at Copenhagen is now approaching completion, and although the plant will not come into operation as soon as it was originally intended, it will probably do so early next year. The position of the station is as central as could be desired. The accumulator room, which is in the basement, is 82ft. long and 66ft. broad; it will, when completed, accommodate two batteries with a capacity equal to supplying current to 2,700 lamps for 3½ hours. The cells are of the Tudor type, and are supplied by the Westphalian firm of Hagen. To the right of this compartment is a commodious boiler-house, 68ft. square and 28ft. high. The present installation comprises six boilers, all tubular, three from Babcock and Wilcox and three from Steinmüller, each of about 300 H.P. There is room for five more boilers should an extension by-and-bye be necessary. In a small compartment close to the boiler-house are three Worthington pumps for feeding purposes. The engine-room is both roomy and well appointed; the dimensions are—length 106ft., breadth 44ft., and height 36ft. There has been some little trouble about the foundations for the engines, which were not deemed sufficiently secure, and had to be reconstructed. There are three engines, all supplied by the well-known local firm of Burmeister and Wain; they are compound, with condensers. One engine is of 300 H.P., and two are of 500 H.P. The condensing water is drawn from the nearest point of the harbour through an underground concrete canal. To each engine two dynamos are coupled direct; these dynamos have an aggregate capacity of some 15,000 16-c.p. There is room for yet another pair of engines. The switchboard has its place at the northern end of the engine-house, and will occupy almost the whole wall; it can, however, be handled by one man, who will have his place on a platform some 15ft. above the floor. On the same level as this platform there is a gallery running round all the four walls of the engine-house, from which gallery there is access to the cylinders of the engines, and the gallery is also on the same level as, and connected with, the offices in the adjoining building. Except in some two or three of the main thoroughfares, where the asphalted lead cables are placed in concrete ducts, the cables (iron armature) are placed direct in the ground, with some bricks over them. The aggregate length of the cables is about 56 miles. The installation in its present form will be sufficient for about 1,400 16-c.p. lamps burning simultaneously, while the present cable system is calculated for 20,000 lamps. The buildings are, however, large enough to accommodate extensions, increasing the aggregate capacity of the installation to 30,000 to 35,000 simultaneously burning lamps. It is, however, not expected that more than 60 per cent. of the lamps installed will be alight at the same time, according to which calculation the present installation will in reality suffice for 23,000 lamps. Up to the present there are applications for about 16,000 lamps.

Another Danish town, Odense, has just got its electric central station; the matter has been started there by a limited company, and not, as in Copenhagen, by the Corporation. The installation, which is not a very large one, has been carried out by a Copenhagen firm; the cables are supplied by Callender's, of London.

An electric installation of considerable interest is the one at Hammersfest, in Norway, the northernmost town, not only in Europe, but in the world. In Hammersfest, four degrees beyond the polar circle, artificial light is naturally of great importance on account of the long polar night, which extends over 66 days. Then, again, artificial light is not wanted at all in the summer, when there is no night for 71 days. The motive power at Hammersfest is a river some two miles distant, and which, an account of the rapidity of its stream, does not freeze even in mid-winter. The electric light is installed in almost every house, and is also used for lighting the streets. It has, so far, given great satisfaction.

CORRESPONDENCE.

HISTORICAL NOTE ON DYNAMO-ELECTRIC MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Nearly 28 years ago (November, 1863), when a mere school-boy, I wrote to one whose memory will be reverenced as long as genius and goodness are esteemed—Michael Faraday. Among other questions I asked the following:—"In an ordinary magneto-electrical machine the power is derived from a steel magnet; would a piece of iron covered with wire do instead of the steel magnet, the iron to form an electro-magnet, magnetised by the magneto-electricity; the iron being first just magnetised by a battery, the future magnetisation being kept up by the current that the magnetised iron itself produces?"

The idea in my mind was, that if we started with an electro-magnet it must first of all be magnetised by an independent battery (I did not allow for any residual magnetism). This magnetisation would enable the armature coils revolving near the electro-magnet to give an electric current, which current was then to be conducted to the wires of the electro-magnet in place of the independent battery, which might now be discarded. We should thus have a magneto-electric machine with an electro-magnet (instead of a steel one); this electro-magnet being kept magnetised by the continued conveyance to it of the current produced by its magnetism in the armature coils turning close beside it. Prof. Faraday most courteously replied to my enquiries, and answered this question by a simple "No." But he added, with that characteristic modesty which was one of his greatest charms: "Your questions would require much more statement and consideration than I am allowed (by my physician) to give to any subject at present, even to researches which, being my own, are obliged to stand still."

Naturally I thought no more about the matter until I became acquainted with the results obtained in 1867, four years later, by Siemens and Wheatstone. I was then greatly interested to recognise in their results the answer to my question, and the great development of the dimly-seen idea, which had occurred to me in 1863. Had the experiment been tried, the exaltation of the magnetism of the electro-magnet, and the consequent increase of the current generated, could hardly fail to have been discovered. These results were, I believe, not foreseen, but were found out by experiment, and are the foundation of the modern dynamo.—I am, &c.,

CHAS. T. WHITMELL,
H.M. Inspector of Schools.

47, Park Place, Cardiff,
November 5, 1891.

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THE WADDELL-ENTZ STORAGE CAR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your American Notes in your issue of October 9th you speak of the Waddell-Entz Storage Car, and you mention that the batteries show a tendency towards irreversible action and disintegration when discharged at a high-current density.

We consider this a very unfair criticism. We find no disintegration of the plates even when discharging at the rate of 600 or 700 amperes per cell. In practice, we discharge at times as high as 400 amperes per cell. Our cells can also be reversed without doing the slightest injury.

We should be pleased to show your American representative these results.—We are, &c.,

THE WADDELL-ENTZ ELECTRIC CO.
W. A. Phillips.

New York, October 30, 1891.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

TENDERS INVITED.—The Corporation of Sunderland invite offers for the transfer (subject to the approval of the Board of Trade) of the powers conferred upon them by the Sunderland Electric Lighting Order, 1891. Further particulars are given in our advertisement columns, and full information may be obtained from the Borough Surveyor, Town Hall, Sunderland. Offers are to be sent in to Mr. Fras. M. Bowey, Town Hall, Sunderland, before the 14th December next.

APPOINTMENT VACANT.—Our advertisement columns contain an announcement that the Corporation of Huddersfield invite applications for electrical engineers competent and willing to superintend the execution of works about to be erected by the Brush Electrical Engineering Company, for the Corporation.

SALES BY AUCTION.—This day (Friday) is the concluding day of Messrs. Wheatley Kirk, Price and Goulty's sale of new electrical fittings, dynamos, &c., &c., at 39, Queen-street, E.C. The sale includes a large quantity of various electrical supplies.

THE EXHIBITION AT ST. PETERSBURG.—Reference was made in the previous issue of *The Electrician* to the forthcoming Exhibition at St. Petersburg. This Exhibition opens on the 13th December, and will continue open for three months. In addition to the Edison exhibits mentioned in our last issue there is to be a phonograph clock, several examples of which have been seen in this country. The latest time for sending in exhibits from Great Britain was September 15th.

MESSRS. A. HALL AND CO.—This firm has recently put down the second largest installation of electric lighting in Liverpool, at the office of Messrs. Henschsberg and Ellis, University House, Islington, Liverpool. The turret of the building has been furnished with an arc lamp, the light from which is visible from the Welsh mountains, and it will doubtless form a beacon for ships entering the Mersey.

MESSRS. CHARLESWORTH, HALL, AND CO.—This firm wish us to intimate that Messrs. Morrison and Harper, of 135, Buchanan-street, Glasgow, are no longer their agents, and that all inquiries should be addressed to their works at Oldham.

LIEPMANN CARBONS.—Messrs. Nicholson, Bolton and Tyler, of 100c, Queen Victoria-street, E.C., have, we learn, purchased the stock of carbons of the late Liepmann Carbon Company, and are placing them upon the market. The plant of the Liepmann Company has been acquired by Messrs. R. Bolton and Co., of 110, Leadenhall-street, E.C.

MESSRS. H. F. JOEL AND CO.—This firm are issuing illustrated printed particulars of the Joel engine and dynamo, the Joel slow-speed dynamo, and the Joel-Pilsen arc lamp. Testimonials accompany the printed particulars.

ANGLO-GERMAN GLASS WORKS COMBINATION.—It is announced that an English joint-stock company is being formed, with a capital of £2,000,000, for the purpose of buying all the glass works in Saxony and Brandenburg. The head office of the company will be at Dresden. The proprietors of 24 works have already consented to sell, and negotiations are still pending with 20 others.

PATENT RECORD.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

APPLICATIONS FOR PATENTS.

September 28, 1891.

16,388. W. S. HAYS, Manchester. An arc lamp.

16,407. H. J. ALLISON, London. Improvements in printing telegraphs. (M. D. Porter, United States).

16,408. H. R. LOW and the Art Workshops, Limited, London. Improvements in electric arc lamps.

16,420. C. B. CALLOW, Tring. Improvements in telephone transmitters and receivers.

16,431. A. MITCHELL, London. Improvements in means and apparatus for telegraphic purposes.

16,451. W. P. THOMPSON, Liverpool. Improved system of electric train signalling for preventing railway collisions. (E. Espian and P. Ferrer, Spain).

September 29, 1891.

16,456. A. G. BROOKES, London. Improvements in electric switch apparatus, or means for controlling electric circuits. (J. P. Cushing, United States).

16,487. H. H. LEIGH, London. Obtaining a fluid for primary batteries and of recovering the effective matter from the spent fluid (J. B. Gardiner, United States).

16,522. W. P. THOMPSON. Liverpool. Improvements in or relating to electrically soldering or brazing metal. (C. L. Coffin, United States).

16,526. H. H. LAKE. London. Improvements in pencils or electrodes for electric arc lamps. (E. Tweedy, United States).

16,530. H. H. LAKE. London. Improvements in and relating to receiving instruments or relays for submarine cable and other electric circuits. (C. G. Burke, United States).

16,549. F. C. HELM. London. Fuse for electric circuits.

16,551. H. H. LAKE. London. Improvements in and relating to transmitting instruments for submarine cable and other electric circuits. (C. G. Burke, United States).

16,572. W. B. SAYERS. London. Improvements in armatures for dynamo-electric machines and motors.

September 30, 1891.

16,641. J. LEWIS. London. An improved coupling for lightning conductors.

October 1, 1891.

16,680. W. H. BLAKENEY. Glasgow. An improved electrical switch.

October 2, 1891.

16,752. D. J. MULLARKY. Bradford. An improved electrical and mechanical alarm clock.

16,767. F. W. S. JENNY. London. Improvements in apparatus for electric cooking and heating.

October 3, 1891.

16,866. A. G. MELHUISH. Peckham. A new or improved method of and means for the electrical propulsion of missiles

SPECIFICATIONS PUBLISHED.

1890.

13,522. ROUX. Electric accumulators. (Price 8d.)

15,248. SISLING AND OTHERS. Dynamos, &c. (Price 8d.)

15,777. MILLS. (Blein.) Electric meters. (Price 8d.)

16,232. SHEPARD. Arc electric lights. (Price 8d.)

16,747. THAME. Electrical insulating materials. (Price 4d.)

16,821. HESKIN. Producing light by incandescence. (Price 8d.)

17,266. FELL. (Richter.) Electric railways. (Price 8d.)

17,558. RATHBONE. Testing electric wires. (Price 6d.)

17,851. BINKO. Electric fire, &c., indicating apparatus. (Price 8d.)

18,206. DAVIS and STOKES. Dynamo-electric generators, &c. (Price 11d.)

18,695. HOLMES. Dynamo electric machines. (Price 6d.)

19,049. MUIRHEAD. Electric lighting appliances. (Price 6d.)

19,068. KINGSBURY. (Western Electric Co.) Telephone switches. (Price 8d.)

20,043. ANDERS and ELLIOT. Telephones and mechanical signals. (Price 8d.)

1891.

3,404. ELLIOT and FURTADO. Telephone switches. (Price 8d.)

10,260. SHIELS and ELLIOT. Electric signalling, &c., in trains. (Price 8d.)

12,898. PARKER. Electric deposition of copper. (Price 8d.)

13,627. BRAIN and ARNNOTT. Electric current motor. (Price 8d.)

13,936. KINNER. Electric motors. (Price 8d.)

14,234. CATTORI. Electric railways. (Price 8d.)

14,322. SAVAGE. (Savage.) Electric light holders. (Price 6d.)

14,786. RILEY. Electric combs. (Price 6d.)

14,962. BROWN. Telephones. (Price 6d.)

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COMPANIES' MEETINGS & REPORTS.

Western and Brazilian Telegraph Company (Limited).

The twenty-second ordinary general meeting of the Western and Brazilian Telegraph Company (Limited) was held at Winchester House, Old Broad street, yesterday, "to receive the Directors' report and the accounts for the half-year ended June 30, 1891, and to declare a dividend." Mr. W. S. Andrews occupied the chair.

The SECRETARY (Mr. R. M. Cunningham) read the notice convening the meeting and the minutes of the last ordinary general meeting, held on May 8, 1891, which were approved by the present meeting and signed by the Chairman as correct. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, before proceeding to the ordinary business of the meeting, I have to announce with regret the resignation of one of the members of our body. It is only a couple of days old, and the first opportunity of considering it was to-day, and I have extreme regret that the gentleman to whom I allude is Mr. Henry Weaver, who has resigned his seat at the Board. Mr. Weaver seemed to think that there were certain incompatibilities in his holding the position, and with his usual straightforwardness decided to relinquish it. The Directors feel such a deep regret at losing so highly esteemed and valuable a colleague that, perhaps, they are not impartial judges. Looking at the eminent—nay, valuable—services of Mr. Weaver for the past 13 years, during times of exceptional trouble and difficulty, they cannot but deplore his loss, and wish him to feel that he carries with him their greatest regard and esteem, as well for his high character as for his undoubtedly superior qualifications as a man of business, and his estimable personality as a friend and colleague. The Directors do not at present propose to fill up the vacancy. The office might indeed be supplied, but the capacity to fill it adequately the Directors do not see their way to; and for the present at all events they have decided to go on as they are, with a united and compact body, thoroughly intimate with the complicated affairs of this undertaking. Gentlemen, that is an unpleasant duty, and it is now fulfilled. I will now proceed with the business. Notwithstanding certain disappointing elements the receipts remain, as they have been lately, of a satisfactory character; and I am pleased to say that we have again to report, as you will have seen from the figures, a very large take on the operations of the half-year. The receipts were £104,962, as compared with £89,846 for the corresponding period of last year, which, of course, is an augmentation of £15,115. With reference to that increase in money, I would remark at this stage that the increase in the traffic is considerably larger than the increase in money represents. There would have been an addition to our receipts if an endeavour that we made to establish a certain claim under our agreement with the Brazilian Submarine Company had been successful. A point was raised under that agreement. We were strongly advised upon it, so strongly in fact that the amount of the claim was included in the published estimates. In the end, however, as showing the glorious uncertainty of anything which arises, or depends, on points of law, the decision was given against us, otherwise our receipts would have been larger. At the same time, of course, that was only a claim, and the result has shown that the claim was not a good one in the opinion of those who had to adjudicate upon it. But dismissing that as something to which we were not entitled, there is a considerable diminution in our receipts, which money, so to say, we have actually earned—namely, we have made a loss on exchange during the half-year under review of £8,197. Now, you see, that is no fault of ours; but if exchange had been at par, instead of at the serious discount that it has fallen to some times, we should have come before you to-day not with an increase of £15,000 but with an increase of upwards of £23,000, and, of course, that is a very large sum of money. If a change should take place in exchange in Brazil we should benefit by it, as we did at one time. We began by losing, then we were benefiting, and now we are losing again. So much for the revenue. Now the expenditure on the whole shows a reduction of £1,871. This, of course, was spread over a number of items, some of which showed increases and some decreases. There are some 15 items in all, and six of them show increases and nine decreases: but, analysing the figures as we usually do, under Abstract A—the expenses at stations—there is, of course, an increase. There is an increase in the number of the staff. New men have had to be sent out to meet the larger business at the end of 1890, the night service introduced in 1891, and the increased work. Then, owing to the state of things in Brazil, we have had, what I am sorry to say we have rather too frequently, a number of resignations. These resignations involve replacement; and replacement, of course, involves increased expenditure. Then there is £182 increase in income-tax, which no one will object to, because it represents increased profit. There is £356 for the new agency at Buenos Ayres, £112 for travelling expenses, stationery £122, new instruments £250, and increased insurance—there being more to insure—£140. The total increase is £1,839, but there were the items I mentioned before—the nine items—which show decreases. It is not worth troubling you with the details of all these, but the result is that there is a net increase under Abstract A of £1,354, as against an increase of £15,000—or £23,000, as it would have been but for the loss on exchange—in our revenue. Under Abstract B—the ships—we show very favourably. The "Norseman" exhibits decreased expenditure of £959, and the "Viking" of £1,581. The items are really too numerous to go into in detail. The ships have been less at sea, they have used less coal, they have been less in dock, and the general expenses—upon which we always keep a very observant eye—have been reduced. The total result is a decrease of £2,540. Under Abstract C—which are the London expenses—there is a small increase of £271, of which £81 is for increased Clearing-house expenses. You all know that, to get customers, you must endeavour to be accurate, and you cannot be accurate unless you have some means of comparing your message forms at the different stations for transmission and reception in order to detect any errors that may have been made, by comparing the copies at the transmitting stations with those forwarded by the sender. That slight increase is occasioned by the increased work of that department, and there is no doubt it pays for itself a great many times over. Then, under profit and loss account, you will find that we have spent £1,344 less upon new cables for repairs. That, of course, is quite an exceptional item, but fortunately it is on the right side. Then there is a small amount paid on account of the telegraphic expenses, which really does not come into this year, for the simple reason that there has not been one. The final result of all that is an increase of revenue of £15,000, earned with a decrease of expenditure of £1,871; and but for the exchange, as I have already stated, the increase in the revenue would have been £23,000; and the extra work representing that money, you must remember, has actually had to be performed. The messages have been worked, only they have not produced quite so much; and when I tell you that the additional work performed by the staff during the past half-year represents an increase over the corresponding period of the previous year of somewhere about between 31 per cent. and 32 per cent., I do not think you will imagine that it has cost more than it ought to have cost. Of course, when we bring out a saving in expense, more work done at less expense is a *non sequitur*—it is nonsense; and therefore it is only right to point out, as I have done, that the additional expense arises under Abstract A, and that applies, of course, to all the points I have named—not merely the transmission, but also stationery, and all sorts of things that are necessary outlays in connection with the working of the traffic. I think that, on the whole, looking at these figures, you must say at least that they are not unsatisfactory. The Directors continue to give anxious attention to the expenses, and they do the best they can to keep them down. Of course, they draw the line at this—that in keeping them down they must not impair the efficiency. Therefore, if the efficiency of our work demands it, we are bound in your interest to spend such an amount of money as may be necessary. There is no doubt that judicious expenditure is really the clue to the expenses of all companies. The upshot of all this is that the gross receipts are £104,962, less working expenses £38,638, leaving a balance of £66,323. Then there was brought from last half-year £6,070; and the dividend received from the Platino Company was £7,387. We therefore arrive at the amount of £79,781. Debiting £12,866. 10s. for debenture interest, and for debenture redemption £6,233. 10s., together £19,090, we get a balance of £60,681. From this, £25,000 has been placed to reserve, leaving £35,681, out of which the Directors recommend the declaration of a dividend of 4 per cent. per annum, the same as for the corresponding period of the previous year, carrying forward £6,470. Well, gentlemen, I think that, looking at our past operations, we must have established in your minds a strong conviction as to the value of a good reserve. The shareholders have been intelligent enough and far-seeing enough from time to time to authorise these amounts being placed to reserve, and the present position is very largely owing to that. Of course that reserve is now considerably depleted. It does not stand at the present moment at the figure that it did on June 30th last. You will see in these accounts that the reserve is set down as being £254,000 odd, but since that date we have had to pay for the new loop cables. We have done that without any addition whatever to the capital account. The whole of it has been provided from the reserve, and that is why I say that you have shown your prudence in former years. The whole of that has been paid for out of reserve which you authorised us to establish. Of course, in consequence of our paying for these cables, the reserve fund stands at a lower figure. It is now £105,000, including the £25,000 that we have placed to it now, as stated in our report. We put this £25,000 to reserve for paramount motives at that time, and even if we had not had sufficiently strong motives to justify that proceeding then, I think what has been occurring within the last week, with which all you gentlemen must be acquainted, is quite justification and quite proof enough that the Board adopted a prudent course. You know that from time to time we have been threatened with competitions, and we have always made a clean breast of this matter, and told you what we were threatened with. Well, to-day we have got to go a step further. One of these competitions has been established, and the cable has been opened for traffic. The line is laid between North America and Vizeu, in Brazil; but it is not extended at the present time all the way to North America, but stops at Santiago de Cuba, and then goes over the lines of the Cuba Company, the International Ocean Company, and the American Telegraph Company. That was opened on September 1st, and I am pleased to be able to say that its effect upon our traffic was really *nil*. I do not mean to say that they did not do anything. They did something, but at all events it was not anything very considerable; and on October 22nd they had the misfortune to sustain an interruption, which still lasts. Consequently, at the present moment that cable is broken down. Of course, in the due fulfilment of time there will be, I suppose, a repair; but, as far as we can ascertain, we do not think there is any very immediate prospect of the repair being effected. Then, again, owing to the termination, most fortunately, of the Chilian war, our old competition by the West Coast of course comes into operation again. If you remember, I told you at our last meeting that our take was greatly augmented because the competing line, *viâ* the West Coast, was interrupted, owing to the Chilian difficulties, and that, therefore, we had a monopoly of the trade. After the conclusion of the war that line was re-opened. The effect of it we cannot very well estimate at present. The only guide we have is that of our receipts. You know, of course, that the receipts of late have been lower than they were at the corresponding period of last year, but then there is the apparent anomaly that our business is actually larger. We are doing more work, but are getting less money for it, and that, again, arises from the low exchange in the last half-year having become still lower this half-year. That materially affects our receipts. We should, if exchanges were anywhere near par, be presenting you with, not decreases, but increases of revenue. We hope to see that

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state of things presently re-established. I have not, however, quite done with new lines. There is another line now being talked about, and some say that the cable is being made, while others say that it is not. The latter say that a cable is being made, but not for this purpose. However that may be, the thing may come forward or it may not. People connected with new companies do not always see the very great difficulties they are going to encounter, and they are apt, with syndicates and one thing and another, perhaps unknowingly, to provide means for those lines to be carried out. They suffer afterwards, not merely by the loss of their capital, but perhaps the whole of their revenue; but they contribute to raise up a lot of companies, with a lot of expenses, and in the end the public pays the expenses of two, three, or four companies, where the expenses of one company would suffice, and the work could be done by that one company with less cost than it could be done by the four companies. However, I suppose that that is too satisfactory a thing for us to hope for. I stated that this new cable, to which I have alluded, was interrupted. Now, all these cables, like the Vizeu cable, are single lines. Therefore, if one single cable is broken, the Company has no communication at all, and to that extent you will see, knowing the care with which you have duplicated your own lines, that these companies are at a decided disadvantage. Well, of course, the efforts of the Brazilian Submarine Company and of ourselves have been directed towards careful preparation for all this competition, and there is no doubt that what with our adequate skilled staff, our loop cables, our duplex apparatus arrangements, and the fact of a loop of our system being the cord line—for it is the most direct line to Brazil—any competing cable that may be laid will have its work cut out in meeting us. My own impression is that we shall be able to hold our own. We are not going to bully these people at all; we are not going to lose our tempers, or get flurried; but we think that, as men of business, if we provide with a certain amount of prescience for the future, and if we establish, as we believe we have established and are establishing, our system upon the best possible footing, with our experience, our knowledge, and with our connection, we ought at least to do considerably better than any of these gentlemen who are coming forward, knowing nothing about the whole business, and with single cables. Well, now, since our last meeting, we have carried out these great cables, these large lines, and, as I have said, we have carried them out entirely from the reserve fund. Originally, the project, if you remember, was to loop from Pernambuco to Rio; but at one of our meetings I informed the shareholders that there was a little congestion upon one of the lines between Rio and Santos, and as the strength of a line and the capacity of a line are that of its weakest link, of course it became very desirable to do away with that link. For that purpose the loop was extended on from Rio to Santos. These lines have rendered extremely good service. The duplex is being extended, and if we have been strong hitherto, I think we shall be a great deal stronger now. Then, of course, it must be remembered that these loops, quite apart from their incidence as affecting competition, are guarantees to a large extent of your revenues. At one time where you had single lines, and where they became interrupted, the losses, as you know, were very great. Your liability now to total interruption is enormously lessened, and, consequently, you are not so likely as you were before to sustain those serious losses of traffic and of revenue. At the last meeting, or the previous one, you authorised the acquisition of the undertaking of the Montevidean Telegraph Company. It was acquired for a payment in shares by this Company, and the purchase price shows us 5 per cent. upon it. Previously to our purchasing it it held a charge upon our gross revenue of so much. Consequently we have substituted dividends on shares if they are earned for a charge upon revenue which must have been paid under any conditions. At the same time, we believe that this is a very good substitution for the Montevidean people, because they were given the benefit of the expenses they were paying, and they get a fair return. The effect of that—to harp on the old string—is to give us increased strength. There was before a separate Board coming on to this link, and we have got rid of that link, and the Montevidean Company is absorbed and has become a part of this Company, with all its cables. Gentlemen, there has very frequently been discussion about some reorganisation of our debentures. Well, a scheme had been prepared with this object. The lawyers were satisfied with it, and said that it avoided all the difficulties, and certain terms could have been carried out; and I did expect to be able to come before you to-day, and to tell you that we were going to launch this scheme; but meanwhile we received a communication from Brazil which has compelled us to pause in your interest for the time being. Of course, that does not affect the merits of our scheme, and does not emanate from debenture holders. I would go into detail, and tell you what the communication is if it were altogether judicious to do so. I do not, however, think that it is, but if any shareholder would like to have the information, it shall be placed fully at his disposal if he will be good enough to call at the offices of the Company. Owing to the competition to which I have alluded, you will observe that there is a cessation in the publication of our weekly traffics. The Brazilian Submarine Company took the step of stopping their publication—I confess I think wisely. I have been of opinion personally that it ought to have been stopped before. (No, no.) Pardon me, I think you will admit, when I say a few more words, that there is a great deal to be said on both sides. I should preface these observations by saying that in the abstract, as I have already told Mr. Fry, we are always in favour of the publication of these traffic returns. The best proof of that, perhaps, is that we have published them. I do not know what better proof I can give you than that; but when you find yourselves threatened with competition, is it a wise thing, week by week, to give these gentlemen full information of the value of the traffic that is being transmitted for which they are working to get a slice? I do not think it is (hear, hear; "Quite right.") Therefore, in conjunction with our partners, who we think acted wisely, we should probably have done the same thing if they had not, and have proposed it to them, the publication has been stopped. I think there is nothing further for me to mention now, and, therefore, with your permission, I will propose—

"*That the report and accounts for the half year ended June* 30, 1891, *as submitted, be and the same are hereby approved and adopted, and that a dividend for the half year ended June* 30*th at the rate of* £4 *per cent. per annum be and is hereby declared payable on the* 13*th inst.*"

I beg to move that resolution, and after it has been seconded I shall be very happy to reply to any questions as far as I can.

Mr. C. W. EARLE seconded the resolution.

Mr. ENNIS asked whether the Chairman had made any reference to the sum mentioned in the second paragraph of the Directors' report of £11,121. 4s., paid in respect of traffic receipts between March, 1889, and December, 1890, hitherto under dispute.

A SHAREHOLDER inquired whether the question had been considered of getting rid of one or both of the Company's ships now that they had duplicated their cables. They had got the new cable referred to on a former occasion, but they now heard nothing further as to what was to be done with the ships, the cost of which was about 1½ per cent. on their share capital, which was a tremendous amount. Of course, they would not save the whole of this amount if they got rid of the ships, for they would have some work to do, which would have to be done by other ships. The question, however, was what would pay best.

The CHAIRMAN: I have very much pleasure to repeat, in reply to the first gentleman, as nearly as I can, the observations I made with regard to the sum he mentioned. That arose under a claim with the Brazilian Submarine Company. We were advised that the claim was good—in fact, we were so strongly advised that the amount was included in our estimates, but when the matter was tried out the claim proved not to be a good one, but a bad one. That £11,000, therefore, which was included in our estimates, but which never really belonged to us, had to be knocked out. With reference to the ships, one of the main reasons for the retention in our service of a large ship—a larger ship than might otherwise have been necessary—has been the fact that some of your cable was in deep water. I did not refer to that, because, though it is mentioned in the report, it does not properly belong to the half-year under review. As a fact, we had 200 miles in very deep water, and that old, unsuitable type of cable remaining—which was a legacy from the former Board to the present Directors—has been gradually renewed out of the system, so to say; and at the end of September or thereabouts—as recently as that—we removed the last section of this unsatisfactory stuff. We substituted for that 200 miles a certain length of new cable, a certain length—some 50 miles surplus—from the expedition to lay the loops, and the remainder was made up by stock. That led us—though there had not been time hitherto for it to do so— to a decision with respect to this particular ship, and consequently to what we have told you has been in our minds all along - the question of some substitution. Now, I may tell you that we have had in the office of the Company—although we have not been in a position to proceed with the matter, on account of that section which is still in very deep water—plans for a new ship, which would be a cheaper vessel to work than the "Norseman"; and now that that old cable is out of the system, we have already considered the matter, and we shall not merely consider it, but we shall come to a decision very speedily upon the question that has been brought forward. Whatever we do in regard to it, we shall, of course, do with a full sense of our responsibilities for the maintenance of your system, which is and must be paramount to us. That has been the first consideration up to the present time. As I say, there is a modification in it now—quite a recent modification—which will admit of further consideration being given to the matter, and that will be done.

Mr. W. GRIFFITH observed that the very able and lucid speech of the Chairman had answered most of the questions that might have suggested themselves to the shareholders. In his remarks, however, the Chairman had stated that the expenditure of the Company had been somewhat increased by resignation of their servants. This did not refer to Mr. Weaver, whose resignation they all deplored; but it was regrettable that they were losing certain gentlemen who were tried and experienced, and more especially was it regrettable on account of the great expense of obtaining successors. He therefore desired to ask whether any plan could be devised by which the Company could retain in their service such gentlemen as those to whom the Chairman had alluded.

A SHAREHOLDER said he was convinced that they would all deeply regret the Chairman's announcement of the resignation of Mr. Weaver. From the very commencement of submarine telegraphy, Mr. Weaver had been one of the principal Directors of submarine cables, and they must all greatly deplore his loss. The Chairman's speech must, he thought, be received by all the shareholders with great satisfaction, considering the latest information they had had from their colleagues, the Brazilian Submarine Company. At the meeting of that Company, the Chairman gave—in, as he (the speaker) thought, rather an extraordinary manner—a most pessimistic view of the position. What applied to that Company also applied, he thought, to the Western and Brazilian Company, and he was therefore sure, from the lucid statement just made by the Chairman, that the shareholders would go away with the idea that if they were going to have all the trouble which was anticipated they would not be wiped out, but would be able to exist and to hold their own. With reference to the question of the publication of the traffic return, in an interview which he had recently had with the Chairman he (the speaker) had stated that he was quite willing to fall into the views of the Directors. If the Chairman thought it necessary that the traffic receipts should not be published, he, as a large shareholder, was perfectly willing to trust them. He thought that up to the present time the shareholders had had every confidence in the manner in which the Chairman had carried out the policy of the Board and also with the results obtained; but, at the same time, he

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trusted that he was not saying too much when he said that if in the future they should receive suggestions—recommendations—from their colleagues of the Brazilian Submarine Company, they would, as a Board, not be too subservient to the views of those gentlemen. They were entirely an independent Company, and did not want to be under the thumb of the Brazilian Submarine Company. They were willing as their colleagues to agree with them and run with them in everything that was reasonable. He trusted that if the competition should come to an end—and perhaps it might never do so—they might see their way again to publish the weekly traffic returns. If they were to have very bad returns, no one was more entitled to know the fact than the shareholders. If they were going to have good traffics—and this was what they desired to keep away from their opponents—he was perfectly willing that the traffics should not be published, and to leave the matter entirely in the hands of the Directors.

A SHAREHOLDER asked whether the information respecting the receipts of the Company would be denied to shareholders who applied at the office. The matter opened up another question altogether, which he did not want to mention there, but it was a subject upon which he would like to hear some expression from the Chairman.

The CHAIRMAN: I think that when the Directors desire, as an abstract question, to give every publicity to the traffics, such publicity, if given at all, must be complete. I do not think it would do for Directors to give to gentlemen applying at the offices this information, because you then have to define what is a *bona fide* shareholder; and I should hardly like to undertake the job.

A SHAREHOLDER stated that he observed in the present balance sheet the sum of £154,000 set down as the expenditure upon new cables, whereas in 1888 the Chairman mentioned as an estimated item £90,000. This was so wide a difference that he would like an explanation upon the point.

The CHAIRMAN: The original reference was made to the cable which was ordered for Brazil, but which we were not allowed to lay. The Government, as you remember, at that time and for some time afterwards was against us. That section of the cable was laid upon another part of the system, and it represents only a small part of the total scheme which has since been carried out.

A SHAREHOLDER observed that it was stated that debentures to the amount of £50,000 would be issued for the new cables.

The CHAIRMAN; Originally the question arose how the funds were to be provided. An unexpected amount of money was earned in one half year; there was a very large balance, and there was a sum of about £26,000 which the Directors, with the shareholders' approval, did not divide in dividends, but recommended the shareholders to put to reserve fund. That £26,000 was, therefore, so much to the good. The reserves have since been satisfactory, and with the approval of the shareholders, I think the Directors have not issued that £50,000 of debentures. We have the power to do so, and that is a nest egg should it be necessary; but if we can avoid it, and manage to build up this reserve fund again, why should we put before the shareholders £2,500 a year if it is not absolutely necessary to do so? (hear, hear.) In reply to the question asked by Mr. Griffith, it is not alone the skilled and the best men who leave us. The old servants remain with us as long as they can, but a great many of the new men who go out, not being acclimatised—and there have been two or three very bad seasons in Brazil—have suffered quite exceptionally; and, not to put too fine a point on it, got "funky" and came back.

A SHAREHOLDER enquired whether any of the staff had gone to the competing companies.

The CHAIRMAN: None as far as I know.

A SHAREHOLDER asked if the £11,000 mentioned in the second paragraph of the Directors' report came out of their total earnings, and whether these earnings had been £104,000 or £116,000?

The CHAIRMAN: The gross earnings are £114,000. The other amount was a claim which was not substantiated, as I have already mentioned. He then put the resolution to the meeting in the usual manner, and declared it carried unanimously, adding that that concluded the business.

Mr. GRIFFITH said he thought the shareholders ought not to separate without tendering their thanks to the Chairman and his colleagues. They were very fortunate at the present juncture in having men of experience at the helm of affairs.

A SHAREHOLDER, in seconding the motion, expressed his conviction that no shareholder would be more pleased to read the Chairman's speech on the following day than the shareholders of the Brazilian Submarine Company.

The resolution was carried unanimously.

The CHAIRMAN: On the part of my colleagues, and on my own part, I beg to thank you for your kind vote, and the manner in which it has been received.

City of London Electric Lighting Company (Ltd.).

An extraordinary general meeting of this Company was held at Winchester House, Old Broad-street, E.C., on Thursday last week, at 3 p.m., Sir David Salomons, Bart., in the chair.

The SECRETARY (Mr. J. Cecil Bull) having read the notice convening the meeting, the following resolution was proposed by the CHAIRMAN, seconded by the EARL of SUFFOLK, and carried unanimously:—

"*That the special resolution which was passed at the ordinary general meeting of the Company held on the 15th day of October, 1891, as follows:—That Article No. 13 of the Company's Articles of Association be altered by inserting after the words 'each call,' at the end of the fourth line, the following:—'and that no call shall exceed one-fifth of the nominal amount of a share, or be made payable within two months after the last preceding call was payable,' be and is hereby confirmed.*"

The CHAIRMAN intimated that this really concluded the business of the meeting, but before separating he would like to say a few words in answer to an assertion he had seen in certain newspapers that he had conveyed an entirely erroneous impression as to the relative cos. of gas and electricity. He said: I will first state that an 8 c.p. glow lamp is usually taken to replace a 5ft. gas burner at usual gas pressure, the light in each case being approximately equal. Again, an 8 c.p. lamp requires from 30 to 33 watt-hours (*i.e.*, ampere × volt hours), and as a Board of Trade unit equals 1,000 amperes × volt hours, it consequently results that at 8d. per Board of Trade unit the cost of 33 8 c.p. lamps for one hour comes out at 8d., if the value of the lamps is excluded. This is arrived at by dividing 1,000 by 33, giving approximately 33·8 c.p. lamps for one hour for 8d. Now, glow lamps are said to last over 1,000 hours before renewal, but in practice they last much longer. We will, however, take the 1,000 hours, and as each lamp costs 3s. 6d., or 168 farthings, then the cost of wear of 33 lamps for one hour is 168/1000 × 33 = 6 farthings, or 1½d.; consequently, the cost of one Board of Trade unit becomes 9½d. when wear of lamps is taken into account: 1 8 c.p. lamp for one hour = 9½d./33 = 1·15 farthings = 1¼ farthings.

Gas being reckoned by price per 1,000 cubic feet, a foot burner consumes 5/1000 = 1/200 of charged price per 1,000 cubic feet. Consequently, with gas at 2s. 6d. per 1,000 cubic feet, a 5-foot burner costs per hour, 1/200 × 2s. 6d. = 120/200 farthings = 3/5 = 0·6 farthing. Gas at 3s. per 1,000 cubic feet, by a similar calculation = 1/200 × 3s. = 144/200 farthings = 0·7 farthing. Gas at 3s. 6d. per 1,000 cubic feet similarly = 1/200 × 3s. 6d. = 168/200 farthings = 0·84 farthing. Gas at 4s. 6d. per 1,000 cubic feet, also by same method = 1/200 × 4s. 6d. = 216/200 farthings = 1·08 farthings. Gas at 5s. per 1 5-feet burner for one hour costs 1/200 × 5s. = 240/200 farthings = 1·2 farthings.

From these calculations it will be seen that the electric light in point of cost lies between gas at 4s. 6d. and 5s. per 1,000 cubic feet; the actual value being over 4s. 10½d and under 4s. 11¾d.

No questions being asked, the meeting then terminated.

West India and Panama Telegraph Company (Ltd.).

The following is the report of the Directors for the half-year ended June 30, 1891, to be submitted to the twenty-ninth ordinary general meeting, to be held at Winchester House, Old Broad street, E.C., on Tuesday next, Nov. 17, 1891, at 2 p.m.:—

The Directors submit the accounts for the six months ended June 30, 1891. The amount to credit of revenue is £47,641. 16s., against £52,351 2s. 4d. for the corresponding half-year of 1890; and the expenses have been £24,868. 16s., against £26.619. 17s. 4d. for the same period in 1890, leaving a balance of £22,773. which, with the balance of £668. 3s. 2d. brought from last account, makes a total of £23,441. 3s. 2d. Of this sum the Directors have placed £2,000 to reserve, leaving an available balance of £21,441. 3s. 2d., with which it is proposed to deal as follows:—First preference shares—dividend, six months to June 30th, 6s. per share, £10,368. 18s.; second preference shares—dividend, six months to June 30th, 6s. per share, £1,400. 14s.; ordinary shares—1s. per share (free of income tax), £4,416. 1s.; balance to current half-year's account, £5,255 10s. 2d.

The traffic receipts for the six months show a decrease of £4,598. 2s. 3d. as compared with the corresponding period.

The expenses for repairs to cables amount to £11,936. 14s. 2d., being £1,999. 14s. 1d. less than those for the corresponding half-year, owing to fewer interruptions.

The shareholders have been informed from time to time of the impending competition of the Société Française des Télégraphes Sous-Marins. This competition assumed an active shape in the early part of June, when that Company's cable was extended from Porto Plata (San Domingo) to the two French colonies, Martinique and Guadeloupe. The rates to and from Martinique and Guadeloupe were reduced by the French Company, and the West India Company also found it expedient to reduce its tariff to the more distant colonies, where, owing to the geographical position, the tariff is necessarily higher than in the more northern islands. These reductions have entailed considerable losses of revenue, and, owing to the marked depression of West India trade during the past few months, there has been not only no increase in the volume of traffic consequent upon the reduced rates, but an absolute falling-off in the number of words transmitted. It is, however, anticipated that this trade will revive next year, as the prospects of the coming sugar crop are encouraging.

In view of the circumstances stated above, and of the large expenditure in repairs during the current half-year, the Directors have deemed it prudent to carry over a larger balance than usual to the next account.

The Company's s.s. "Grappler" is now engaged in laying the new cable between Trinidad and Demerara.

A contract has been entered into with W. T. Henley's Telegraph Works Company for the manufacture and shipment of 250 nautical miles of deep-sea cable for stock.

Woodhouse and Rawson United (Limited).

The following is the annual report of the Directors to be presented to the shareholders at the general meeting to be held at Cannon-street Hotel, London, E.C., to-day (Friday), November 13, 1891, at 12 o'clock.

The Directors present herewith to their shareholders the report and balance sheet for the past year. Of the second issue of capital authorised at the last general meeting, namely, 20,000 ordinary shares, 10,000 preference shares, and 100,000 £5½ Debenture Stock, 9,889 ordinary shares, 7,000 preference and £85,192 Debenture Stock have been allotted. The balance sheet shows a net profit of £35,103. 9s. 2d., which, with the sum of £16,335. 15s. 3d., the amount brought forward from last year, makes a total of £51,439. 4s. 5d. Out of this sum the Directors paid, in February last, an interim dividend at the rate of 8 per cent. upon the preference shares, and 15 per cent. upon the ordinary shares, and they now recommend a further dividend up to June 30th last at the same rates.

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These payments will absorb the sum of £30,507. 16s., and leave the sum of £20,931. 8s. 5d. Out of this balance the Directors recommend the appropriation of £10,000 to the reserve fund, which will then stand at £35,000, £1,500 to bad debt reserve, and the addition of £500 to the *employés'* pension fund, bringing this up, with interest, to £1,565, and leaving £8,931 8s. 5d. to be carried forward to the current year's account. With a view of enabling the balance sheet to be prepared up to as late a date as possible, the accounts for all the branches are made up to May 31st, stock being taken to that date, whereas the head office accounts are made up to July 31st.

West Kensington Hall, Hammersmith.—During the last year these works have been increased by the erection of a large new factory, 133ft. by 44ft. and five storeys high, fitted with all the latest appliances. The old engines and boilers have been replaced by those of the latest and most efficient type, the old chimney has been pulled down, and a large one erected, whilst the foundry has been enlarged, and the works generally improved. The cost of the new buildings has been put to capital account, whilst of the cost of moving, £2,000 has been written off revenue account. Although alterations have not been carried out without considerable interruption of the work in hand, the turnover has largely increased, and it is hoped that this extension will enable the Company satisfactorily to keep pace with the work offered in this department. The power for the whole of the new factory is transmitted by electric motors placed on the different floors. One of the Company's buildings has been fitted up for the manufacture of the Epstein accumulator, one of the inventions mentioned in the report of last year as being tested, and which has more than borne out the expectations that had been formed of it.

Union Foundry at Kidsgrove.—These works have been consolidated, a new boiler-shop erected, and new plant put down. The mortgage which was existing on the property when it was taken over has been substantially reduced. The works are at present very busy, and there is every prospect of a considerable development of trade in the future. An extension of this branch has been made by the acquisition of the business of Messrs. Anderson and Gallwey, hydraulic engineers, for whom the Company had been manufacturing, and who have a large number of specialties in hydraulic machinery now taken over by the Company. Mr. Gallwey remains with the Company as manager of this department. The patents of Mr. Reginald Bolton for electric cranes and winches have also been purchased, and promise to bring in a considerable amount of valuable business.

Cornbrook Telegraph Works.—These works at Manchester have been extended by the erection of special plant for the manufacture of dynamos and motors, the works having had hitherto a difficulty in supplying the orders in hand.

Supply Department.—This important department has continued to increase rapidly, the turnover for the last year having considerably exceeded that of the previous year, and the net profit has doubled. The increase has been such as to necessitate a wharf being leased for the heavier goods—viz., Lyon's Wharf, Thames-street, E.C. This increase since the date of the balance sheet has been maintained. The acquisition of the new warehouse and showroom is giving satisfactory results.

Installation Department.—A large number of contracts have been carried out, and at the present time the amount of work in hand is larger than at any previous period. Amongst the contracts at present in hand is one for the erection of electric lighting plant for public lighting in the streets of Johannesberg. The central station plant supplied by the Company for Barcelona is working thoroughly satisfactory.

Bradford Branch.—This portion of the business, from whence the installation work in Yorkshire is carried out, has given progressive results, and the supply of goods in the North is being now dealt with from that centre.

With regard to the department for testing and proving of new patents and inventions, to which your Directors drew attention in their last report, and at the general meeting, as likely to add materially to the profits, a large amount of business has been offered and examined. Out of the four important electrical inventions undergoing process of testing, mentioned in the previous report, only one has turned out sufficiently well to justify this Company in introducing it to the public, this being the Epstein accumulator, to acquire and develope which the Epstein Electric Accumulator Company (Limited) has been formed, with Mr. Epstein as Managing Director, and from which this Company looks for important pecuniary results.

Out of other new business in course of investigation by your officials, one, after close examination by your Managing Director, has turned out satisfactorily, and gives promise, on its introduction by your Company at an early date, to command great attention.

The Directors feel themselves justified in alluding to the various Elmore Copper Depositing Companies that have been introduced to the public under the auspices of your Company. As the technical statements made have been proved by actual results, your Directors not only believe that the several Companies will fulfil the expectations held out by us, but will exceed them, and they have therefore entertained proposals for a further development of the process in other countries at an early date.

The sum of £75,000, lodged by Woodhouse and Rawson, Limited, with this Company as guarantee fund for the payment of a minimum dividend of 15 per cent. per annum up to the 30th June next, has been repaid that Company, under the authorisation given to that effect at the last general meeting.

Under the articles, two Directors retire, Mr. Samuel Pope, Q.C., and Mr. Philip Rawson, who being eligible offer themselves for re-election. The auditors, Messrs. Pixley and Co. (now Messrs. Jackson, Pixley, Husey and Co.), retire according to the articles, and offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

BENFIELD (LIMITED).—This Company was registered on November 4th, with a capital of £50.000 in £10 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are to acquire and carry on the business of "horse shoe manufacturers, blacksmiths, iron and brass founders, boiler makers, mechanical and electrical engineers, &c.," carried on by Benfield and Co., at Walsall, Staffordshire.

CONCENTRIC SEAMLESS STEEL TUBE COMPANY (LIMITED).—This Company was registered on November 5th, with a capital of £20,000, in £5 shares, by Beale and Co., 28, George-street, Westminster. The objects are :—To carry on the business of tube manufacturers, carried on at the Dartmouth Works, Dartmouth-street, Birmingham, by G. J. Rossiter, and to carry on the business of manufacturers of weldless steel tube for locomotive, marine, and other boilers, hydraulic presses, boring rods, spindles, torpedoes, &c. The first Directors are G. J. Rossiter and G. W. Holt.

EAST COAST ENGINEERING COMPANY (LIMITED).—This Company was registered on November 4th, with a capital of £2,000 in £10 shares, by R. B. Nicholson, Lowestoft. It intends to carry on the business of mechanical and electrical engineers, founders, land, marine and gas engine manufacturers, dealers and repairers, manufacturers of heating apparatus, &c. Registered without articles of association.

GLOBE ELECTRIC COMPANY (LIMITED).—This Company was registered on November 4th, with a capital of £10,000, in £1 shares, by Messrs. Gover and Chiles, 71, Queen-street, Cheapside, E.C. Its objects are :—To acquire by purchase, lease or otherwise, or to improve, manage, work, develop, sell or otherwise deal with property of all kinds, and in particular electrical and mechanical engineering businesses, including chemical engineering, electrical and other works, &c. The number of Directors is not to be less than three nor more than five, the first to be nominated by the subscribers to the memorandum and articles of association.

SECTIONAL STANDARDS (LIMITED).—This Company was registered on November 3rd, with a capital of £3,000 in £10 shares, by Wood, Bird and Wood, 16, Eastcheap, E.C. The objects are :—To acquire and develop an invention of improvements in telegraph poles. The first Directors are Messrs. F. H. Lloyd, F. N. Cowell, and F. W. Drewitt.

BRITISH ELECTRIC INSTALLATION CONTRACTORS (LIMITED).—The first registered office of the above-named Company, which was registered on October 12th last with a capital of £20,000, in £5 shares, is situated at 1, Angel-street, Worcester (filed on November 7, 1891).

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—The registered office of the above named Company has been removed from 112, Belvedere-road, Lambeth, S.E., and is now situate at the Albert Buildings, 49, Queen Victoria-street, E.C.

GORDON ELECTRIC TRACTION COMPANY (LIMITED).—The statutory return of this Company, made up to December 24, 1890, was filed on November 5, 1891. The Company was registered on August 13, 1890, with a capital of £2,400, in £10 shares, to acquire and develop the invention of John Gordon of a system of electric street-car traction, for which provisional protection was granted May 5, 1890, and numbered 6,083, and to carry on experiments at Messrs. Merryweather and Sons' works at Greenwich, for the purpose of showing the value of the invention. John Gordon was allotted 60 shares in consideration for the said invention, and was appointed Managing Director, with a salary of £4 per week. At the time of the making up, 172 shares had been taken up, of which 60 were considered as fully paid. Upon the remaining 112 the full amount was called, and £860 paid, leaving £260 unpaid. The principal shareholders are J. Gordon, of 13, Nettleton-road, New Cross, electrical engineer (52 shares), and W. Lüttge, of 17, Gracechurch-street, E.C. (36 shares), Registered office: Messrs. Merryweather and Sons' offices, Greenwich-road, Greenwich S.E.

OGMORE VALLEY ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—The statutory return of the above-named Company, made up to October 22nd, was filed on November 4, 1891. The Company was registered on June 10, 1891, with a capital of £10,000 in £5 shares, to supply the Ogmore Valley, in the county of Glamorgan and neighbourhood, with electric light ; 569 shares have been taken up, upon all of which £1 per share has been called, and £434. 10s. has been paid, leaving £134. 10s. unpaid. All the shares have been taken up locally. No agreements for the acquisition of works, plant, contracts, &c., have as yet been filed. Registered office : 2, Wyndham-villas, Nantymoel, near Bridgend, Glamorganshire.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts of this Company for the week ended November 8th amounted to £783 ; aggregate receipts for half-year to date, £13,546.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED). Notice is given that on Thursday, November 19th, will be drawn 312 Five

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per Cent. Mortgage Debentures of £100 each, for payment on Jan. 1st, 1892. The drawing will take place at the Company's Offices, 50, Old Broad-street, E.C.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to allow the additional shares Nos. 101 to 6,100 of this Company to be quoted in the Official List.

SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The accounts of this Company for the year ended September 30, 1891, have been passed, and, subject to audit, the Directors recommend the shareholders to declare a dividend at the rate of 6 per cent. per annum for the six months ended September 30 last, and of 5 per cent. for the twelve months ended at the same date, making, together with the interim dividend declared in May last, a total dividend for the year of 11 per cent.

WEST COAST OF AMERICA TELEGRAPH COMPANY (LTD.).—The traffic receipts of this Company for the month ended October 31st were £3,000.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LTD).—The traffic receipts of this Company for the half-month to October 31st were £1,990, as compared with £2,741 in the corresponding period of last year. The June receipts, estimated at £4,755, realised £4,503.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Nov. 4.	Price Wednesday, Nov. 11.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Nov. 11. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12,6	Anglo-American	49 50	48½ 49½	5 1 0	Jan., Apr., July, Oct.	49½	48¾
£2,849,510	Stock	25/0	Do. Preferred	87 88	86 87	5 17 11	" "	87½	86½
£2,849,510	Stock	5/0	Do. Deferred	12¾ 13¼	12¼ 12¾	.. ..	" "	12⅝	12⅜
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July	..	..
130,000	£10	5/0	Brazilian Submarine xd. and Bonus	10¾ 11¼	10½ 11	7 5 6	Mar., June, Oct., Dec.	11	10½
£69,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	135 140	135 140	5 0 0	April and October	139	136
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3⅛ 3⅜	3 3⅛	6 13 4	April and October	3⅛	..
6,000	5	10%	Do. Preference 10%	9¾ 10¼	9½ 10⅛	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10¾ 11⅛	10¾ 11	6 7 3	Jan., Apr., July, Oct.	10⅞	..
400,000	10	2/6	Eastern	14½ 14⅝	14 14½	4 11 3	" "	14⅝	14½
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15⅝	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock xd	106 109	106 109	3 13 5	May and November	107½	106
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	15⅛ 15⅜	14⅞ 15⅛	4 12 7	Jan., Apr., July, Oct.	15½	15
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	106 109	106 109	3 13 5	February & August	..	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104 107	104 107	4 13 6	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	102 105	102 105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99 102	99 102	3 18 5	January and August	100⅛	..
180,227	10	2/0	Globe Telegraph and Trust	9⅜ 10	9⅜ 9⅞	5 8 10	Jan., Apr., July, Oct.	10	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	14½ 15	14⅜ 15	4 0 0	" "	14⅞	14⅜
150,000	10	5/0	Great Northern	18½ 19½	18½ 19	4 9 6	Jan., April, and July	18⅝	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	107½	..
17,000	25	12/6	Indo-European xd	41 43	41 43	5 16 3	May and November	42½	41½
38,348	10	5/0	London Platino-Brazilian	6½ 7½	6½ 7½	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	7⅜ 8½	7⅜ 8½	4 16 11	April and October	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6% April coupon, £2	118 123	118 123	4 17 7	" "	..	..
15,609	10	6/0	West African Telegraph	7½ 8½	7½ 8½	5 17 8	January and July	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	98 101	97 100	5 0 0	March & September	98	97
30,000	10	2/0	West Coast of America	2½ 3½	2 3	.. ..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	98 103	97 102	7 16 10	June and December	..	..
88,321	10	9d.	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	.. ..	May and November	1⅜	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	8⅜ 9½	8⅜ 9½	6 9 9	" "	9⅝	9
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7⅜ 8½	7⅜ 8½	7 1 2	" "	..	..
61,653	15	9/0	Western and Brazilian	10½ 10⅝	10½ 10⅝	7 9 3	" "	10⅝	10⅜
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4 4½	4 4½	.. ..	" "	4½	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	101 107	104 107	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage xd	118 122	118 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance. xd	7/16 9/16	7/16 9/16	7 9 4	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	7/16 9/16	7/16 9/16	6 8 11	Yearly	..	..
438,984	5	3/6	National	4⅜ 4⅝	4¼ 4½	6 13 4	June and December	4 1/16	4 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13	12½ 13	4 12 4	" "	..	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12 13	12 13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	106 108	106 108	4 3 4	.. ..	107½	107
58,000	5	1/0	United River Plate	1 2	1 2	.. ..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 Sh.)	4⅛ 4⅝	prem ⅛ ⅜	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
5,322	£5	..	House to House Electric	4½ 5	.. ..	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅜ 2⅝	2⅜ 2⅝	..	March and February	..	..
10,000	5	..	Do. (fully paid)	4⅛ 5⅛	4⅛ 5⅛	..	" "	..	..
111,000	£5	..	London Electric Supply	1⅜ 2⅛	1⅜ 2⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	10 10½	10 10½	..	..	10½	10⅜
6,318	10	..	Notting Hill Electric Lighting (£8 paid)	6 7	6 7	..	..	..	..
7,730	£5	3/6	St. James' and Pall Mall	8½ 8¾	8¾ 9⅛	..	..	9	8 5/8
..	..	7%	Do. 7% Preference	7½ 7¾	7½ 7¾	..	..	7⅝	7 5/8
42,853	5	..	Westminster Electric Supply (£5 paid)	6 6¼	6 6¼	..	..	6¼	6⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
£2,850	10	..	Blackpool Electric Tramway	.. ..	.. ..	..	..	..	..
77,978	3	1/8	Brush Electrical Engineering	3⅜ 3⅝	3⅜ 3⅝	4 19 9	..	3 5/8	3 1/16
69,996	2	6%	Do. 6 per Cent. Preference	2⅛ 2⅜	2¼ 2⅜	5 2 8	..	2⅜	2¼
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5 5⅛	5 5⅛	6 7 3	January and July	..	..
17,130	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	6½ 7	6⅜ 7⅛	..	—	7	6⅜
70,000	2	10/0	Elmore's Patent Copper Depositing	3¼ 3½	2⅞ 3⅛	..	—	3⅜	2⅞
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20 21	20½ 21½	4 15 3	February & August	21	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	6 7	6 7	.. ..	January and July	..	..
11,334	£10	8/0	Do. Preference	8½ 9½	8½ 9½	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅞ 1	⅞ 1	.. ..	..	..	..
78,949	5	11%f'r yr	Swan United (£3. 10s. paid)	4⅜ 5⅛	4⅜ 5	7 13 10	May and November	5 1/16	4⅞
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July	43½	42½
50,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	102 105	4 15 3	January and July	103⅜	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2⅛ 2⅜	2⅛ 2⅜	15 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	3¾ 4	3¾ 4	10 0 0	..	..	..
			RAILWAYS.						
50,000	£10	—	City and South London Railway	3 4	3 5	—	—	—	—

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

The application of the City of London Electric Lighting Company for an extension of one year in the time of their street-lighting contract, which is recorded in our "Notes" columns, appears by all accounts to have excited rather a strong expression of feeling on the part of those present at Tuesday's meeting of the Commissioners of Sewers. The *City Press* refers to the petition as a painful surprise, and states that the text of the communication caused considerable indignation, and talks of "the vexatious delays which have already occurred in the electric-lighting operations within the City."

The present Company can, we doubt not, make out an excellent case for itself. It only came into existence in July last; the consent of the Board of Trade and of the Commissioners of Sewers to the latest transfer of contracts was only obtained at the end of August; there has been tightness in the Money Market; the Pioneer Company could not be expected to involve itself in a large outlay until the financial success of the existing concern was assured; the work is one of considerable magnitude and some difficulty; everything is *now* being done to make up for lost time; the extension asked will probably never be taken advantage of. All this may be urged, but the broad fact remains, and alone interests the public, who cannot be expected to follow intricate company evolutions or realize why the running of a few hundred arcs should be the cause of so much pother—that although the contract for the Central District was signed on December 3, 1889, and that for the Eastern District on January 28, 1890, yet so far the only outward and visible signs are the 26 arc lamps in Queen Victoria-street. We cannot but think that this application for still more time is to be regretted.

Just as we go to press we hear that at last, after protracted "interference," lasting since 1877, the United States Patent Office has issued the microphone patent; but whether to Berliner or to Edison the press cablegram does not say. In either case the affair is the property of the American Bell Telephone Company. The granting of a patent for the microphone thirteen years after its discovery is certainly a grotesque proceeding, according to our insular notions; but, fortunately, it is a purely local custom. The American microphone monopoly has now a fresh lease of seventeen years.

Another and a similar telephone patent "interference" case is also apparently drawing to a conclusion. According to the *Electrical Review* of New York, Commissioner Simonds, of the American Patent Office, on October 25 rejected an appeal from a decision of the Board of Examiners-in-Chief in connection with the Drawbaugh patent. This question has been in a state of litigation for more than eleven years. The Commissioner found that the improvement in controversy "was in public use and on sale for more than two years" prior to Drawbaugh's application.

The Blackpool Tramway continues to be the best evidence that we have in this country that electric traction can be made to pay. It again pays a dividend of 7½ per cent. on its paid-up capital of £20,000, and adds a relatively substantial sum to the reserve fund, which now stands at £6,000. The number of passengers carried since the last report has been 933,692, or nearly 15 per cent. more than last year, the car miles run being 98,000, as against 92,000, an increase of only a little more than 6 per cent. The figures put down for conduit, and for motor and gear repairs seem very reasonable, viz., £144 and £192. There are now 12 cars running, so that the latter figure comes out at only £16 per car, which is about 5 per cent. of their cost, and about 13½ per cent. of the original cost of the complete electrical fittings.

Most of our readers who visited Frankfort Exhibition saw the experiments of Dr. Frölich which were shown in Messrs. Siemens and Halske's Court, and which brought before the eye in a very pleasing manner an optical reproduction of the current curves in certain cases of current flow in conductors and condensers. We publish this week a short account of these experiments, and it will be seen from this that to obtain this optical reproduction of the current curves, a telephone is used having a mirror on its diaphragm, after the fashion of Prof. Perry's steam indicator. These curves show curious oscillations and wavelets superimposed on the main curve. It might be thought that these were due to oscillations of the current. A study of Dr. Frölich's Paper, however, will show that the superimposed wavelets are really due to the natural period of vibration of the telephone diaphragm, and that they are of the nature of a defect in the means of observation, just as the effects of vibration of the spring in an ordinary steam indicator diagram disturb the true curve due to variation of steam pressure alone. It does not appear as if we had as

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yet a means at our disposal of rendering visible, by an optical method, the true form of a current curve, and that when accuracy of determination of the form of an alternating current wave is essential, the methods of determination of instantaneous values, such as described by Dr. Louis Duncan in our present issue, or such as have been employed by Prof. Ryan and many others, are to be preferred.

We are sure that no letter from Mr. Crompton, especially when it deals with so important a question as the use of electric motors, will fail to receive the most careful attention of our readers. In the communication which he sends this week he says that "the first question put by an intending user of a labour-saving appliance is not what will be the cost of power and attendance required to run it, but what will be its first cost, and in what time may he expect to repay this first-cost by the economy it introduces." We would go farther and suggest that many small concerns will think even more about the first cost than about the saving. A copper kettle is cheaper in the long run than a tin one, but this economy becomes a luxury on account of its first cost. We welcome this point, which was not considered in our recent article, and hope that it may materially assist the sale of motors. As to the cost of running, Mr. Crompton's figures are very interesting; but they go to prove our contention that it is *only in so far that the work is intermittent* that a small motor is cheaper than a gas engine; and this saving will be inversely proportional to the load factor, but there is a balance of several pence to make up before the saving becomes positive. The concluding remarks about superseding line shafting by separate motors touches a totally different but extremely inportant matter. We look forward to a great development of this system, which gives much satisfaction wherever it has been tried.

Is an apology needed for alluding to a "magnetic lady" in these columns? To describe all her tricks would, indeed, be out of place here, but they are fully set out in the London papers of this week. Anything magnetic concerns us; and anything alleged to be magnetic at least deserves comment, whether it be a fraudulent electropathic belt, or a mistaken and hence a misleading use of the term. The performance at the Alhambra on Saturday afternoon last was extremely interesting to those who were invited to witness the experiments; and though it may be a pity that some sort of tests, mechanical, not to say scientific, were not made, it can hardly be expected that they would be allowed. A "committee" was selected from the invited audience. About twenty persons went on the stage; but only one face was known to us, viz., that of Mr. J. B. Verity. In him the electrical trade was adequately represented. The last name, not on the list, but on a visiting card, apparently self-invited, was that of the notorious electropathic quack, in whom electrical science may be said to have been thoroughly misrepresented.

We had an excellent opportunity of seeing the performance, but failed to see any evidence whatever that any force was being exerted beyond the fact that there was a good deal of apparent struggling, puffing, and redness of face on the part of those who took part in the experiments. When a strong man is learning to ride a bicycle or to skate he expends an enormous amount of force, but nine-tenths of it is misplaced and mysteriously disappears; he is thoroughly tired after an hour, during which he has done no more work than a child could do in a few minutes. Before devoting any more space to this matter we want scientific evidence that any considerable force is exerted. A spring balance would do, or a definite and measured deflection of a cue. The bare arm is of course a mere blind to avoid such a test; but let the man who thinks that he is lifting stand on a weighing machine. If he adds Mrs. Abbott's weight to his own, we will open our columns to a discussion on the matter. We will not question Mr. Verity's acquaintance with the Alhambra stage, but it is surprising that with his commercial abilities he should expect that the manager would allow any real test to be made.

Owing to pressure on our space we have been obliged to hold over our New York correspondent's letter until next week.

Prof. Rücker.—The Royal Society has awarded Prof. Rücker one of its Royal Medals for this year.

St. George-the-Martyr Vestry.—This Vestry has agreed to consent to the Provisional Order of the County of London Electric Lighting Company.

Crystal Palace Electrical Exhibition.—Mr. Musgrave Heaphy has been appointed to supervise the various installations, as far as fire risk is concerned, during the forthcoming Electrical Exhibition.

The Fire at Messrs. Laing, Wharton and Down's.—The many friends of this firm will be sorry to learn that a serious fire occurred at their Works last Tuesday night. Arrangements are, however, being made to execute orders as promptly as ever.

The Determination of Currents in Absolute Electromagnetic Measure.—In the issue for November 13th the following foot-note was omitted from the right-hand column of page 34:—"In order to make Figs. 32 and 33 harmonise, in Fig. 32 P should change places with Q and P′ with Q′."

Glasgow.—The Glasgow Town Council on Thursday last week discussed the question of taking over the whole of the tramway system within Greater Glasgow, and resolved by 50 votes to six to take over all the lines on the termination of the lease, two and a half years hence.

Royal Society.—The following Papers were down for reading yesterday before the Royal Society:—"The Thermal Emissivity of Thin Wires in Air," by Prof. Ayrton, F.R.S., and H. Kilgour; "On the Time Relations of the Excursions of the Capillary Electrometer," by G. J. Burch.

Hammersmith Vestry.—At the last meeting of this Vestry the application of the Putney and Hammersmith Electric Light and Power Supply Company was referred to the Electric Lighting Committee. It was also decided to hold a special meeting of the Vestry on December 9th, to consider the Committee's report.

Cable Communication in the Indian Ocean.—Alluding to the terrible damage done by a recent cyclone in India, the Calcutta correspondent of the *Times* says:—The disaster has again brought into prominence the necessity of laying telegraph cables to the Andamans. The want of such cable is the greatest defect in the Bay of Bengal storm warnings service.

Systems of Electric Traction in the United Kingdom.—There are at the present moment only about 29 miles of tramway in this country worked by electricity, though there are no less than

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four different systems. Five lines, having a total length of 15½ miles, are worked on the third-rail system; accumulator cars run over two lines 4¼ miles long; and the bare aerial conductor system is favoured by three lines, having a length of 7¼ miles; finally, there is but one example of the open-conduit system, viz., the two-mile line at Blackpool. The third-rail system comprises, therefore, about 50 per cent. of the total mileage.

Utilisation of Water-Power in Switzerland.—The Canton of Berne has granted a concession for the utilisation of the water-power of the River Aar at Wynau for electrical purposes. By means of a canal, 1,100 yards long, a fall of 12 feet and a flow of water of 22,000 gallons per second, developing 3,000 effective horse-power, can be obtained. The power thus obtained will soon be taken advantage of in the thickly populated industrial districts of Central Switzerland. It is, moreover, intended to work the proposed Valsthal-Langenthal Electric Railway. Should the power mentioned be found insufficient in course of time it can without difficulty be increased to 6,000 horse-power, as the whole of the water embraced in the concession has a fall of 28 feet.

Owens College, Manchester.—At least two Bishop Berkeley Fellowships (value £100 for one year and renewable for a second year) are offered for award in December next. Applications must be sent to the Registrar on or before December 1st. Evidence of ability to prosecute some special study or research must be presented. A fuller statement of particulars and conditions will be found in our advertisement columns. A limited number of Honorary Research Fellowship appointments will also be made in December next. Applications must be made on or before December 1st. There are no emoluments attached to these Fellowships, but Fellows have equal opportunities for research in scientific subjects to those enjoyed by the Bishop Berkeley Fellows.

The Electric Lighting of the City.—At Tuesday's meeting of the Commissioners of Sewers, the Engineer said he had a communication of the greatest importance to lay before the Court, but seeing that nearly all the members had left he did not think its contents should be read except before a full Court. As a matter of fact, it was an application by the City of London Electric Lighting Company praying for an extension of time for one year in the lighting of the City. He was sorry he had not had an opportunity of bringing the letter up before, but it only reached him on the previous day.—Mr. Smallman said the matter was of such importance that he would move that the communication be printed and circulated among the members immediately.—This was agreed to.

Underground Railway Projects.—In the ensuing Session of Parliament a Bill will be promoted to obtain power to construct an underground railway from Waterloo Station, passing under the Thames on the west side of Hungerford Bridge to a point near the Charing-cross Station of the District Railway. Thence the railway would proceed under Northumberland-avenue, Trafalgar-square, Haymarket, Piccadilly-circus, Regent-street, Regent-circus, and Portland-place to its termination at Baker-street Station.—The Hampstead, St. Pancras, and Charing-cross Railway has notified its intention of seeking powers next Session to construct an underground railway from Hampstead to Charing-cross, the line of route following as nearly as possible the main thoroughfares between Charing-cross and the north-western suburb.

The County Council and the Testing of Meters.—We printed on page 26 of our last issue a letter from a Mr. G. W. Hemming complaining of delay on the part of the London County Council in testing electric meters sent to them. Some further correspondence has taken place, from which it appears that, although some 35 Shallenberger meters were sent to the Council on the 23rd of September, it was not until the 9th of October that the Board of Trade notified to the County Council its approval of any type of meter, without which approval the County Council could not proceed to test. Some difficulty has also been experienced at the County Council's laboratory in Cranborne-street in regard "to testing for the alternate current," a difficulty, which, it is stated, "will take some little time to overcome." It is hoped that a few meters may be certified within a fortnight, but some few weeks more must elapse before the additional apparatus found necessary for testing will be ready for regular work.

The Protection of Telephones.—According to an engineering contemporary, it has been found necessary in America to protect the telephones by the three following devices:—Firstly, currents exceeding 450 volts are shunted to ground by an air cut-out, consisting of two carbon plates separated by a perforated sheet of mica, thin enough to allow the arc to jump through the orifice and set up a connection to earth. Secondly, a fuse which will be melted by a large current is introduced into the circuit. These fuses generally consist either of an easily fusible wire in a glass tube, ⅛in. in diameter, and 5in. long, or tinfoil between asbestos paper. Thirdly, a ball of wax, about ⅜in. in diameter, rests against the coils of an electro-magnet, and when it becomes softened by the gradual warming of the magnet coils it becomes flattened by the pressure of a spring bar pressing against it, and this motion in turn shunts the apparatus out of circuit.

French Electrical Installation Rules.—The French "Union" Fire Insurance Company has procured from MM. Bunel and Picou a full report as to the precautions which in their opinion should be taken in the use of electricity. The principal recommendations of the report are as follows:—The current density is not to exceed 2 amperes per sq. mm. (1,300 amperes per sq. in.) in wires of 10 sq. mm. (No. 9 B.W.G.) section and above, and 3 amperes in the case of smaller wires. Bare conductors are to be prohibited in buildings, and only allowed in exceptional cases in workshops. The protection of the conductors must be doubled, electrical and mechanical. The current leakage must not exceed one-thousandth of the total flow. The use of earth, or of gas or water pipes, or metallic girders, for return currents, is forbidden. The fuses must be double, and must melt with not more than a three-fold current. Resistance-coils must not be heated more than 100° C. Glow lamps must not be put on gas-fittings unless the gas is definitely cut off. Every place containing accumulators to be classified as dangerous, and to be subject to special precautions. Places where gas and electric fittings coexist to be classified as dangerous or very dangerous. The fire risk of gas lighting being represented by 4, the report concludes by estimating the risk as 3, when the electric lighting stands alone and the above regulations are strictly carried out; as 3 to 5, if there be any imperfection in the fittings; as 6, if gas and electricity be both used for lighting; and as 4, if the gas be used only for driving motors.

Brighton.—The Brighton Town Council, who are at present supplying part of Brighton with the electric light from works of their own, had before them yesterday a report of the Lighting Committee, recommending, as the result of certain negotiations, that the Brighton Electric Light Company be paid £7,000 for their goodwill, on condition that they relinquished their business within the Corporation lighting area on receiving a month's notice, and that they cease their supply in other parts of the municipal borough on receiving a year's notice, which, however, shall not terminate earlier than December 31st, 1893, the Company also undertaking not to apply to Parliament again for powers to supply the light in Brighton. The Company to retain their plant and take down their overhead wires.—The Company at starting proposed that the Corporation should take over the whole of its undertaking within the borough, including works and plant, at the price of £17,500. The Corporation refused. Negotiations, therefore, proceeded for the purchase of the goodwill alone, and for this the Company asked £13,000. This offer was subsequently reduced to £10,600, then to £9,850, then to £8,500, £7,500, and ultimately to £7,000. The price offered by the Committee was at first £6,000, but in the middle of the negotiations this was increased to £7,000, at which sum an agreement was at length arrived at. The purchase money is to be paid at once. The additional output thus to be acquired is estimated at 72,400 units per annum. According to the *Sussex News*, the outlay already incurred in connection with the Corporation Electricity Works has exceeded the estimate by £5,000.—After considering the subject in private yesterday (Thursday) the Council rejected the proposal.

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Sydney.—Prof. Threlfall and Mr. E. C. Cracknell have presented their report on electric lighting to the City Council. For street lighting it is proposed in the principal streets to employ 431 2,000 c.p. arcs hung on poles 35 to 40 feet high, 90 yards apart. The mains for the arcs will be underground. The less important thoroughfares are to be lighted by 25 c.p. incandescents with overhead wires. For private lighting a 20,000 light plant is recommended. The total cost for the installation of the street lighting system is estimated at £105,696, and the total annual cost of maintenance at £15,833, or a little over £24 per annum for each arc, and £3. 12s. for each incandescent; the cost of installation of the private lighting plant is estimated at £60,737, and a reasonable profit is figured out on the basis of 8d. per B. T. U. (gas = 5s. 6d. per thousand). The present annual cost of the street lighting is £12,500. The City Council are now considering a Bill giving them powers to establish a system of electric lighting, to grant concessions for private lighting, and to borrow a sum not exceeding £250,000.

City and Guilds Technological Examinations, 1891.—At the recent examination the total number of worked papers was 7,416, as against 6,781 in 1890, showing an increase of 635, the corresponding increases in the two previous years being 175 and 440. This year, too, there is not only an increase in the number, but also in the proportion of candidates who have succeeded in satisfying the examiners, the number of passes being 4,099 as against 3,507 in 1890, and the percentage of passes 55·3 as against 51·8. Examinations were held this year in 53 as against 49 subjects in the previous year, and in 245 as against 219 different centres throughout the country. In the subject of "Mechanical Engineering" there has been a falling off in the number of candidates since 1888. It is thought that this continuous decrease in the numbers during the last four years is partly due to the character of the Syllabus of Examination, which, it is feared, is not as well adapted as it might be to the requirements of artisans engaged in this important branch of industry. The syllabus published in the new programme has been accordingly to some extent revised, and its further revision is under consideration. In "Telegraphy" the number of candidates has risen from 117 to 206. In "Electric Lighting," 392 candidates presented themselves this year as against 256 in 1890, and the number of successful candidates has increased from 173 to 262.

The Electrical Utilisation of Water Power in Sweden.—The utilisation of water power in Sweden through the medium of electricity is, says *Engineering*, a question which is forcing its way to the front. One of the waterfalls likely to be first dealt with is the Trollhättan; and a committee, consisting of five members, has just been appointed by those interested to thoroughly investigate the matter. A calculation has already been made with regard to the transmission of power from the waterfall to Gothenburg (about 40 miles distant). It is expected that some 7,000 H.P. would be required in Gothenburg, leaving out of consideration joineries and sawmills, which produce their own fuel. The cost of electric transmission is calculated at 70 kr. (£3 18s.) per horse-power per annum, irrespective of the cost of the waterfall itself, and the present prices for power in Gothenburg are put at 66 kr. (£3 13s. 6d.) for large concerns, 77 kr. (£4 5s. 6d.) for medium-sized, and as much as 200 kr. (£11 2s.) per horse-power per annum for the small industries. From this it appears that the large industrial establishments are not likely to derive any material benefit from the electric power, and if these are left out there only remain about 2,000 horse-power, for the sake of which it might hardly be worth while installing an electric power plant. If an electric light installation, however, could be connected with the power transmission, the affair would assume another aspect, and in all probability prove remunerative if the waterfall could be obtained free of charge or at a nominal cost.

The St. Pancras Vestry Central Station.—At the weekly meeting of the London County Council on Tuesday the Finance Committee reported that they had considered the application from the Vestry of St. Pancras for a loan of £60,000 for electric lighting works, repayable in 42 years. With regard to the period of years over which the loan should be spread, the Council was precluded from making advances to Vestries for works other than street improvements and bridges, for more than 30 years; and as the engines, boilers, dynamos, batteries, &c., could not be expected to last for above half that period, the Committee were of opinion that the usual course should be adopted, viz, to limit the period of repayment to the assumed life of the respective works, although they considered that the works being expensive and unremunerative at the outset, the repayment might be deferred for a period of two years. They recommended that the application of the Vestry should be granted to the extent of £56,300, on condition that the loan was taken up at once, interest being charged thereon at the rate of £3. 5s. per cent. per annum. Mr. Eccleston Gibb said that the policy indicated in the report would, if carried out, have the effect of destroying the work. If it were impossible for the Council to lend the money to the Vestry on the terms asked, it would be necessary to go to Parliament to borrow, and Friday was the last day on which notice could be given. Mr. Wetenhall pointed out that St. Pancras had taken the initiative in the matter of electric lighting, and that the demand for it in the parish was larger than could be supplied. Ultimately the paragraph was taken back.

The Ether.—The following letter, which appeared in the *Engineer* of October 30th, will probably be read by many with sympathetic interest:—

SIR: In the present day the ether has come to play an overwhelmingly important part in physical science. The whole fabric of the theory of light is based on it: without it radiant heat could, we are told, have no existence. Electricity and magnetism are manifestations of some ethereal action. Is it not about time that physicists enunciated some views concerning this ether which could be understood? Sir W. Thomson has written concerning it largely, and has built up a wonderful gyroscopic structure, with spinning tops within spheres, and called this the ether. Dr. Lodge tells us that the ether is a continuous elastic fluid, without structure or weight. The dynamo shears this fluid asunder, and the desire of the cut surfaces, so to speak, to unite, manifests itself in what we term electricity. It seems to be clear that Dr. Lodge and Sir William Thomson cannot both be right. Again, it has been definitely stated by a French physicist that it is impossible to explain all the phenomena of light, save on the assumption that there are at least six different ethers. An English professor of eminence said years ago that the whole theory of light was tottering to its fall, because of phenomena which no conceivable ether could account for. I ask, now, in all seriousness, if it is not time that some authoritative pronouncement should be made concerning this same ether. Is it, for example, a molecular elastic fluid of great density pervading all space, and of discrete structure, or is it a jelly-like homogeneous body? If it is absolutely imponderable, it must, I take it, be absolutely without inertia or momentum. But if it has neither inertia nor momentum, how can it transmit energy? Let us suppose that radiant heat travels at the same rate as light. When the sun sends us a foot-pound's worth of radiant heat energy it will be eight minutes on the road. What is it stored up in during those eight minutes? In the ether? It seems to me that on such points as these numbers of able men must think very clearly. Now I, and no doubt many other engineers, would like to have equally clear views, and we naturally turn to eminent physicists for light and leading. Which of them will help us?—A. T.—Westminster, October 26th.

Electricity in Mines.—The following extracts from a Paper read by Mr. Albion T. Snell, before the South Wales Institute of Engineers, may be of interest. At Newbridge Rhondda Colliery it was required to drive two pumps 700 yards apart off the same set of mains, each was to be completely independent of the other, and the electric lights must not be affected by their operation. The generator was over compounded to give a constant pressure near the centre of the system, with the result that both the pumps can be switched off without appreciably raising the voltage of the lamps. The dynamo, running at 800 revolutions, gives a pressure of 300 volts and 60 amperes Each of the motors gives 7 B.H.P., and runs at 800 revolutions per minute. The lamps are coupled, in series of three. The pumps are three throw rams, 4in. in diameter by 9in. stroke. An interesting plant, illustrating the conversion of water power into electrical energy and its utilisation for light and power, has been also designed by Mr. Snell. One thousand yards from the Greenside Lead Mines, near Ullswater, there is a 100 H.P. waterfall. A turbine, running at 1,000 revolutions per minute, is coupled by belt to a 100 E.H.P. 4-pole transmission dynamo, compound wound, to give 625 volts and about 900 amperes. The energy is transmitted by a bare wire 19/15 S.W.G. to the mine, and there lead-covered cables are used to convey the electricity to the various motors. These run a winding plant of 10 B.H.P., a pumping plant of 10 B.H.P., and another winding plant of 20 B.H.P. is under consideration. Electric light will be used at different points of the line, and other motors will soon be installed for various purposes.

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ON THE DETERMINATION OF ELECTRIC CURRENT CURVES.

BY DR. O. FRÖLICH.

Electrical engineering has long since arrived at the stage at which it became desirable to ascertain the form of the curves determined by the relation between the current and the time in various cases. The first instances in which this necessity arose occurred in connection with telegraphing on long cables or circuits of large capacity: more recently the influence of self-induction and capacity on alternating current practice has come to the front.

The slowly moving curves such as were met with in cable telegraphy were directly recorded by well-known apparatus such as Sir William Thomson's syphon recorder and Siemens and Halske's soot writer; for the quickly moving curves such as are found with alternating currents, these instruments are too slow, and apparatus has had to be used with which we can measure the current at stated intervals and then set out the curve from the measurements so obtained. Although this method gives accurate results it does not supply the want felt by engineers when carrying out experiments: for this purpose some arrangement is required which will at once exhibit the curve as it is produced, so that any alteration made in the apparatus can be observed immediately on the curve, and the latter can be recorded in a simple and practical manner.

This problem is similar to that which occurs in registering sounds, and it is accordingly only natural that we should first investigate the methods which have been successfully applied in this case. The best known of these is that of Lissajous', which was also frequently adopted by von Helmholtz in his experiments on sound. After having worked for some time on these lines, and arrived at certain results, the method was abandoned, inasmuch as it gives not the actual curve but its development on a cylindrical sleeve, and because, consequently, the various portions are not set out with equal accuracy. In such experiments the bodies from which the curve is to be obtained must undergo a motion of the nature of such a vibration as occurs in a tuning-fork. For electrical curves a telephone, on the membrane of which a mirror was fixed excentrically (*i.e.*, between the centre and the circumference), was used with success, the current which was to be investigated being allowed to circulate in the coils.

When a telephone thus arranged was used in combination with a rotating mirror, such as is often used in physical experiments, and a powerful beam of light after reflection at the telephone and the revolving mirror allowed to fall on a screen, the required curve was at once obtained in a form readily observed. Since, however, this curve was not at rest, but moving over the screen, it was not possible to examine it with the necessary accuracy. In order to bring its oscillations to a fixed position on the screen *the two motions, that of the rotating mirror and that of the telephone membrane, must be combined in a definite manner.* If the apparatus was so arranged that one electric oscillation—*i.e.*, one movement backwards and forwards—of the membrane corresponded exactly with one revolution of the rotating mirror, and the latter contains only one reflecting surface, a part only of the curve, though *fixed in position*, was obtained, the beam at each passage over the screen tracing the same curve at the same spot, and the illuminated curve appearing stationary when the motion was rapid. In order to arrive at this result the movements of mirror and telephone must be performed in time with one another.

In order to obtain the whole of the curve, and of such a magnitude as would be convenient for photographing for instance, and also to get it repeated as often as possible, the rotating mirror was provided with a number of reflecting surfaces, and the proportion between the number of mirrors passing and the period of electric oscillation rigidly fixed. A series of rapidly succeeding illuminated curves was then obtained in the same place on the screen, and these could easily be observed, examined, and photographed.

This arrangement also possesses the great advantage that the process of production is *independent of the speed* of the mirror and the electric oscillation; the wave-length of the image remains constant. In this way, then, the effect of an alteration in the current period on an electric curve may easily be observed, and the process may readily be applied in the case of long-cable telegraphy, induction coils, alternators, &c.

As a source of light a powerful arc lamp was used, and in order to obtain a parallel beam of somewhat small section, the ordinary combination of lenses was adopted. Fig. 1 shows the optical arrangements. B, arc lamp; L l, lenses; o, screen with small aperture; s, telephone with mirror; R, revolving mirror; S, screen on which are thrown the images of the curves.

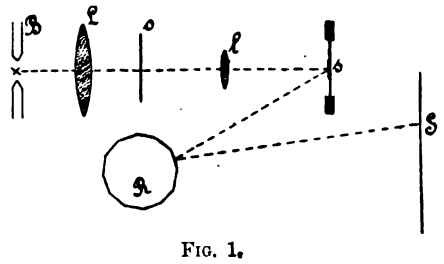

FIG. 1.

The revolving mirror was provided with 12 silvered reflectors, and a special device was adopted in order to bring these parallel to the vertical axis of rotation and at equal angles to each other. The mirror was fixed to a gear-wheel, driven off the spindle of a small alternating motor; for investigation with direct currents a commutator such as is used on small dynamos was fixed to the motor spindle.

The proportions were ordinarily so chosen that the wave-length on the screen came out at about 12cm., and the amplitude 6cm. In a darkened room an audience of 200 persons could then see the curve without leaving their places. When

FIG. 2.

photographs were to be taken, a camera with a plate was used instead of the screen.

The curves given by this apparatus do not necessarily correspond to the current in the telephone coils, but to the movements of the membrane actuated by it. In order that the former curve may coincide with that which we wish to investigate, a membrane must be obtained which shall reproduce as accurately as possible the current curve. This desideratum, however, also enters into the production of a good telephone, and consequently we cannot do better than use an ordinary telephone membrane.

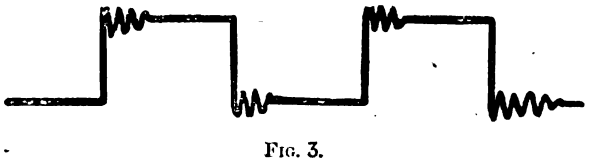

FIG. 3.

I found from my experiments and the theory that every membrane acts like a damped pendulum; the motion of the membrane taking place in accordance with its proper period of vibration and the damping force, as well as with the alterations in the current. We can determine the two former values for a given membrane by opening and closing, at regular intervals, a circuit passing through the telephone, an inductionless resistance, and a set of accumulators. The current-curve must in this case be that given in Fig. 2: the telephone, however, gives us that in Fig. 3. From a comparison of the two the two constants of the membrane, namely its period and the damping, can be ascertained. When these are known, any curve of the current flowing through the telephone can be deduced from that produced by our method by means of [redacted]raphic construction.

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It is only in the case of sudden alterations in the current that any considerable difference between the current curve and the membrane curve arises. When the changes take place comparatively slowly, as in an ordinary sine curve, the ob-

Fig. 4.

served curve gives that of the current sufficiently exactly. Practically, then, the curve need only be corrected in the case of sudden current changes, when the effect of the period of the membrane becomes marked, and then a mean curve is drawn taking these vibrations into consideration (*see* Fig. 4). In most cases this is sufficient.

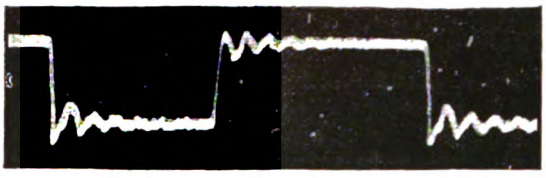

Fig. 5.

Fig. 6.

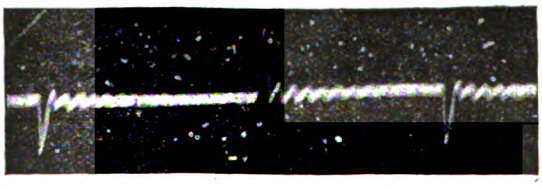

Fig. 7.

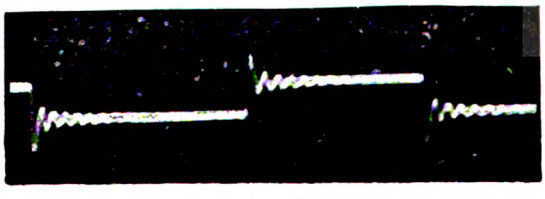

Fig. 8.

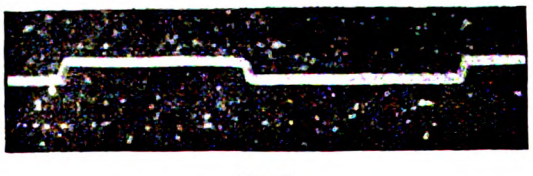

Fig. 9.

We give some of the curves obtained with the apparatus. The figures are reproductions of the original photographs. The figures 5 to 11 are battery curves, such as are obtained on switch[illegible]n and off a battery working on an external circuit. W[illegible] the battery is opened the external circuit is simultaneously closed. The time of each current impulse is about $\frac{1}{10}$ second.

Fig. 5 is produced when the external circuit is practically free from self-induction. The influence of the vibration period

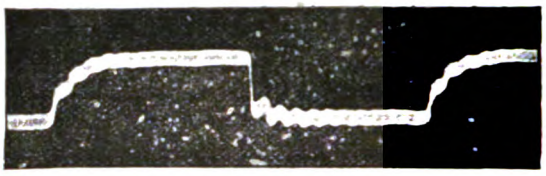

Fig. 10.

Fig. 11.

Fig. 12.

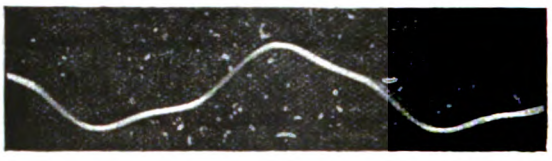

Fig. 13.

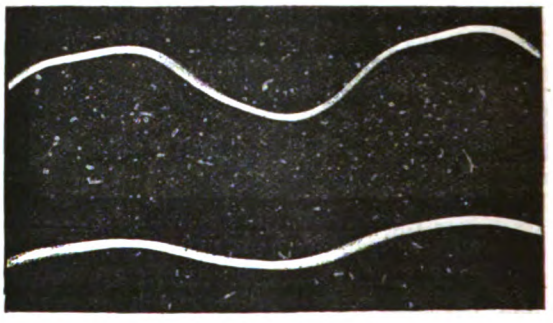

Fig. 14 and Fig. 15.

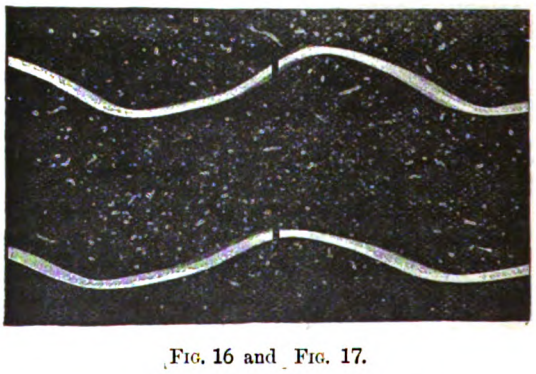

Fig. 16 and Fig. 17.

of the ordinary telephone membrane is here distinctly perceptible.

In obtaining Fig. 6 the membrane was replaced by a cardboard disc, to which was attached a small piece of thin sheet iron. The vibrations due to the proper period of the membrane

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are here much stronger than with the ordinary membrane, and it is difficult to make out the real current curve. Since the card membrane gives a bad representation of the current curve, it must also when used in a telephone give a bad reproduction of speech. This was confirmed by a direct experiment.

Fig. 7 shows the charge and discharge of a condenser, the circuit being almost free from resistance.

Figs. 8 and 9 give the current curve at the beginning and the end of a small cable, current impulses being taken from a battery. The former shows clearly the charging and discharging of the cable; the latter is smaller, and is apparently free from indications of charge.

Figs. 10 and 11 show the current in the primary and secondary windings of a transformer without an iron core. The retarding influence of self-induction when the current changes makes itself felt.

The curves in Figs. 12 to 17 were obtained with a small Siemens alternator. In Figs. 12 and 13 a resistance almost without self-induction was placed in the external circuit. In Fig. 12 the armature producing the current consisted of wire only. In Fig. 13 an iron core was used in the armature.

It is obvious that these curves differ considerably from a sine curve. The rise and fall are different, and the use of iron produces secondary maxima and minima.

Figs. 14 and 15 show curves obtained on circuits of the same resistance, self-induction being provided in the former case by means of an electro-magnet, the latter being without such self-induction. The amplitude and mean current in the former case are clearly smaller.

Figs. 16 and 17 show the difference in phase in two external circuits in parallel, self-induction being put in in the one circuit only. The black band in the two curves is the shadow of a rod that was attached to the screen on which the images were produced in order to arrive at a fixed time mark. In one curve the mark falls by chance at the maximum of a wave, whilst in the other it is a quarter of a wave length to the right. I may here remark that the determination in this manner of the phase difference in alternating currents, wherever an iron core exists, gives results quite different from those to be expected from theoretical considerations.

From the foregoing examples it appears that this method is well fitted for obtaining reproductions of any desired current curves in a direct manner; and in particular it seems to call for some new explanation of the behaviour of alternating currents, in investigating which hitherto one has been compelled to be satisfied, even in experiments, with taking mean values for the electrical quantities. The above investigations were conducted at Messrs. Siemens and Halske's laboratory in Berlin (vide *Elektrotechn. Zeitschr.*, 1889, p. 345).

PRELIMINARY NOTE ON A METHOD FOR DETERMINING THE PERIODIC CURVES OF ALTERNATING CURRENTS.

BY DR. LOUIS DUNCAN, JOHNS HOPKINS UNIVERSITY.

The experimental methods heretofore used for the determination of current and electromotive force curves in alternating circuits present many difficulties, and are cumbersome and tiresome. Most of those now in use are based on the experiments of Joubert, who obtained the E.M.F. curve of a de Meritens dynamo by making instantaneous contacts between the dynamo circuit and measuring circuit at different points on the E.M.F. curve. This method was modified by Messrs. Wilkes, Hutchinson, and myself,* to give curves of primary and secondary E.M.F. and current in alternating circuits containing transformers, condensers, &c. Our method has been copied by Prof. Ryan and others, and the results which we obtained some years ago have been duplicated and extended. M. Blondlot has recently still further modified the method by using a galvanometer, through which a condenser charged to a potential representing different points on E.M.F. curves is discharged, the deflections being photographed. By using two contact, making arrangements or wipers, with two galvanometers, two curves were obtained at the same time.

The difficulties of most of these methods lie in the very considerable potentials used on the commutators—as much as 1,500 volts in some experiments—the fact that only one curve can be obtained for each commutator, with the possibility of error due to the contacts.

The following method is simpler and gives better results. To get the four curves of primary and secondary E.M.F. and current, four small dynamometers are made, and their stationary coils wound for primary current, primary E.M.F., secondary current and secondary E.M.F. respectively, their movable coils being connected in series in circuit with a few storage or other cells; this latter circuit having one end connected with a contact point on the dynamo shaft, the other end connected to a wiper touching the contact point at each revolution. The wiper is moveable through the arc of a circle (180deg. is sufficient unless the curves are to be photographed). These dynamometers may be cheaply and quickly made with wooden spools and a quartz fibre suspension, the current being carried by pieces of coiled tinsel or fine wire, as in a d'Arsonval galvanometer. Four of them may be easily made in a day.

In making the experiments, the deflections of the dynamometers are either observed or photographed. It is evident that if the instantaneous current in a moveable coil occurs when the current in the stationary coil is zero there will be no deflection; if the latter current is at its maximum, the deflection will be a maximum; while, for intermediate values, the deflection (I am considering small deflections, of course) will be proportional to the instantaneous value of the current in the stationary coil. By moving the wiper through 180deg. continuously, if we are photographing* we get all of our curves simultaneously, with no possibility of altered conditions changing their relative values. A galvanometer in circuit with the moveable coils allows an absolute scale to be applied to the curves after the dynamometers have been once calibrated, and eliminates any error caused by the wiper. We are thus able to obtain any number of curves simultaneously with only one commutator, with only a few volts on this commutator, and with no possibility of errors due to the contacts.

* *Electrical World*, March, &c., 1888.

* If the curves are to be photographed the wiper should be slowly reversed.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, November 20th. (To-night.)

PHYSICAL SOCIETY.

5 p.m. Paper to be read:—"A New Theory concerning the Constitution of Matter." By Dr. C. V. Barton.

TUESDAY, November 24th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Papers to be discussed:—(1.) "Portland Cement, its Manufacture, Use and Testing." By H. K. Bamber. (2.) "The Inspection of Portland Cement for Public Works." By A. E. Carey, M. Inst. C.E. (3.) "The Influence of Sea-Water upon Portland Cement, Mortar, and Concrete." By William Smith, M. Inst. C.E.

WEDNESDAY, November 25th.

SOCIETY OF ARTS.

8 p.m. Ordinary meeting. Paper to be read:—"Measurement of Lenses." By Prof. Silvanus P. Thompson, D.Sc., F.R.S.

THURSDAY, November 26th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting, continuation of Discussion on the following Paper:—"Description of the Standard Volt and Ampere Meter used at the Ferry Works, Thames Ditton." By Capt. H. R. Sankey and F. V. Andersen.

FRIDAY, November 27th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read:—"Modern Railway Carriages." By Walter Clemence, Stud. Inst. C.E.

JUNIOR ENGINEERING SOCIETY.

8 p.m. Presidential Address by Sir E. J. Reed, F.R.S., M.P.

ELECTRIC HARMONIC SOCIETY.

8 p.m. Ladies' Night, Concert at St. James's Hall Restaurant.

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ELECTRIC LIGHT CABLES.

The method of specifying the insulation of electric light cables for house-wiring seems to be in a rather unsatisfactory condition. There are three elements to be considered: insulation resistance, the nature of the insulating material, and its thickness. The first of these appears to be of the greatest importance in the opinion of many persons, among whom may be included most cable makers. The hundreds or thousands of megohms per mile are sure to be given in their price lists, whether the nature of the insulation is described or not. For submarine cables the number of megohms per mile is no doubt important; every megohm has its duty to perform; and in street work, where the conduits may be flooded, the insulation indicated by this description may sometimes be put to trial. But for house work the uselessness of these megohms is proved by the fact that enquiries are rarely if ever made as to the conditions under which their value was arrived at. A contractor desirous of doing good work will avoid any cable described as offering less than 300 megohms per mile; but he very rarely thinks of making enquiries about the duration of immersion, the volts under which the test was made, how long they were applied, or, indeed, whether an electrification or bridge method was used. The temperature of the test is occasionally given in the price list, a detail which is of as much importance as whether salt water or fresh was used. When only three or four megohms per house are required, a contractor will not make a fuss about hundreds per mile; but, at present, these meaningless megohms are his chief guide to the quality. The Chelsea Electric Supply Company indeed demand 600 megohms per mile, and say nothing whatever about megohms per house. The mere fact that the ultimate insulation of the circuit in an ordinary house is about the same as that of several hundred miles of the cable used shows the unsatisfactory state of the present custom. Before the art of wiring was understood, an

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important part of the work consisted in making joints; and these were so often a source of trouble, and the weakest part of the circuit, that it was common, in making an inspection, to lay bare one or two for examination. But now that joints are confined to distribution boards, and are otherwise either absolutely forbidden, or are reduced to a few large and easily-looked-after instances, the leakage is to be traced almost entirely to fittings; but we may look in vain in the price lists for a guarantee of so many megohms per switch or lampholder. The excellent china fittings that are made to-day, with no screws coming through from the back, are an example of the improvements which are accepted readily enough, because common sense shows that a well-considered attempt has been made to combat with leakage. A careful contractor uses them in the hope that his insulation will be better, but he never thinks of them as being of a definite insulation resistance.

The second element, that of quality, has been attended to of late, partly because it was found to be impossible to get the insulation demanded by the supply companies on a house wired for 50 lights, with wire of inferior quality. We do not remember ever having seen a price-list offering a resistance less than 150 megohms per mile; the insulation of the lower classes is discreetly passed by in silence. Another reason, however, is the persistent effort of Mr. Musgrave Heaphy to exact the best qualities only; and while much annoyance was felt at one time when vulcanized rubber was demanded, a result has been that almost all makers have put down vulcanising plant, and there is no difficulty in getting cables so insulated. But a consulting engineer does not like to specify a particular kind of insulating material. Another kind may turn up, and he finds himself unable to say why it should be excluded, while to mention the names of particular makers is invidious. If he gives several names, and classes Brown's AA, Jones's G, and Robinson's X, picking those which are of similar or comparable material and of corresponding insulation resistances, the contractor, being relieved of responsibility, will compare prices, and will take that which he can buy best. But comparisons of price-lists are very bewildering. One maker sells 7/16's for £75 per mile and puts it at 2,000 megohms, while another charges £79 for the same size of conductor with 300 megohms. The general public are beginning to have some notions about volts and amperes; but this comparison would convey nothing to the average man except a confused idea that one manufacturer sold with his cable something called a megohm at 9d. apiece, while another charged about 5s. 3d. He would, of course, be told by an electrician that this conclusion was quite wrong, and, by way of clearing the matter up, the latter would perhaps explain that the expression megohm-miles, not megohms per mile, would be the more correct. Unsatisfactory as this mode of description of the quality of cables may be, it is very difficult to find any better. It will not do to specify the insulating material, as was done in the original draft of the overhead wire regulations of the Board of Trade. If, as in that case, india-rubber be specified, vulcanised bitumen will be offered by one maker and a mysterious compound called okonite will be produced by another; and these cannot be rejected as inferior in any way to the older and better known material. Some new mixture may be introduced any day; and it is surprising that coal tar has not yielded some "waste product" of suitable electrical and mechanical properties. The worst quality of insulated wire may be avoided by a suitable specification, but the best cannot be ensured without insisting on these thousands of megohms, which are not really necessary.

It will not do to merely specify the thickness of the insulating material and its composition, for after all some insulation resistance is wanted, even though it need not amount to many hundreds of megohms per mile. Most manufacturers maintain a proportion between the diameter of the conductor and the external diameter of the cable. A certain thickness of insulating material is necessary to resist mechanical abrasion. A wire covered with cotton and saturated with shellac serves for a dynamo armature; and although careful makers cover the core with mica before winding, there are thousands of dynamos in use with only a layer of tape between the wire and the iron. But this sort of insulation, though electrically efficient, would never do for wiring a building. In cases where high volts are employed the thickness of the insulating material does more than merely increase the actual insulation resistance; and the thickness specified in the overhead wire regulations was, we believe, intended as a precaution against sparking through any accidental cracks in the covering. Even if the large external diameter is really necessary, it need not in this case be built up entirely of the best insulating material.

The prices and qualities of electric light cable do not differ more than those of boots. Tenders to a careful specification for boots run, so we are informed, very close together; but the price is somewhere about 5s. 6d. a pair. We asked the manager of a large West End business if the first-class quality of boots could possibly be ensured by specification, and he admitted that he could not see how it could be done. But nobody says that bootmaking is in its infancy because the price varies from 5s. 6d. to £3 per pair. The safest way to get a first-rate electric light cable or a good pair of boots is to go to a first-rate maker. The smaller men may say that this is hard on them; and it is these smaller men who have their opportunity when asked to tender. It is all the more important, therefore, that it should be possible to describe the really essential qualities of a cable properly in a specification.

A case occurred recently in Cologne, not indeed of house-wiring, but of mains laid in the streets, where the difference between the tested insulation resistance of the cable and its resistance when laid was indeed fully realised by the authorities. The guaranteed insulation of the cables was fixed at 700 megohms per kilometre before laying, but only 7 megohms per kilometre were demanded after laying. The actual insulation of the completed work turned out to be 1,600 megohms per kilometre, measured with low volts and a mirror galvanometer. The cable, which was of Berthoud-Borel make, stood a subsequent test of 5,000 volts. We were sorry to observe that in the course of a recent trial some cable which was badly cracked and unfit for outdoor work was said by more than one witness to be adapted for house-wiring. The difference in price between good and bad cable per house is quite insignificant compared with the variations between one tender and another. A contractor may, and generally does, find some cable maker who suits him, and he knows by experience that a certain quality of cable is satisfactory, and does not trouble himself about its description when he is not working to a specification. Some people think that there is a vast amount of good india-rubber and other material buried away in casing which is practically useless, and that only in the remote contingency of the bursting of a water-pipe will its insulating property be called into play, and that this contingency may be provided against by a cut-out. But it has been proved over and over again that inferior insulation in the presence of damp will gradually deteriorate, and may ultimately char any neighbouring wood, so it seems advisable to stick to the hundreds of megohms; but it would be well to know rather more clearly than at present what each maker means by this description of his goods.

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A FORGOTTEN TELEGRAPH PIONEER.

MR. JACOB BRETT.

At the ordinary general meeting of the Institution of Electrical Engineers on Thursday evening last week, the usual preliminary business was agreeably diversified. The President announced that the Council had elected Mr. Jacob Brett an honorary member of the Institution, in recognition of his valuable services in connection with the introduction of submarine telegraphy. He also announced two very interesting donations, viz., an excellent portrait in oils of Mr. Jacob Brett, painted and presented by Miss Alice Bolton, of 49, Blomfield-road, Maida Vale; and seven volumes of manuscript letters and manuscripts formerly belonging to the late Sir William Fothergill Cooke, relating to the introduction into England of the electric telegraph by himself and his partner, the late Sir Charles Wheatstone, presented by Mr. Latimer Clark.

Mr. LATIMER CLARK, in acknowledging the vote of thanks to himself, and in seconding a similar vote to Miss Bolton, said: I have great pleasure in seconding this motion, but before referring further to the subject I feel bound to return my thanks for the kind way in which you have accepted from me the letters, documents, and papers of the late Sir William Fothergill Cooke, which I have had the honour to present to the Institution. Anyone who looks into these letters will find their perusal very interesting, and I can vouch for the fact that they are historically extremely valuable, because they relate to the history of the introduction of the electric telegraph into this country at a date so early that it is not possible that anything earlier can be discovered. We owe it to the business aptitude and energy of Sir William Cooke, assisted by his partner, Wheatstone, that the electric telegraph was introduced on the railways in this country at a very early date and before it was taken up by other countries; so that Great Britain will for all time to come claim the honour of having first introduced the electric telegraph into practical use, as it can also claim the first invention of electric telegraphy through the celebrated letter of "C.M." in "The Scot's Magazine" of 1753.

Although I knew Sir William Cooke extremely well and for a great number of years, it was a long time before I could induce him to entrust to me the valuable papers he had in his possession. For many years I used, on every opportunity, to urge on him that they should be deposited in some public institution, and it was only some ten years ago that he at last consented to place them in my hands, as part of a large collection of works which I had been accumulating, and which I assured him would sooner or later find their way to some public library. When I did obtain possession of them, a great many were found missing, in spite of every search he could make. They now comprise seven volumes, containing all kinds of documents of a legal or business nature, and a great many private letters. Perhaps the most interesting part of the collection is a series of private letters to his mother and his brother, detailing the inception and early development of his ideas. He was most affectionately attached to his mother, and his letters to her abound in expressions of filial love which are quite touching. They were written in the old days of high postage rates, and, as was customary in those days, they were crossed and recrossed in such a way that it is difficult to read them, and would be still more difficult to find space for an additional 20 words in any of them.

Our honorary solicitor, Mr. George Bristowe, has very considerately made a copy of all those portions which relate to the electric telegraph, and this will be found in a separate volume. He has done this not only with a view to their more easy perusal, but he was impressed with their historic value, and he kindly undertook this duty with a view to their safe preservation from fire or other accident, deeming it unsafe that only one copy should be in existence. I will venture to read an extract from the first letter to his mother, dated April 5, 1836, because it is always interesting to trace the first movement in a path from which such mighty results are afterwards destined to emanate.

"Heidelberg, April 5, 1836.

"MY DEAREST MOTHER: You must know that for some weeks past I have been deeply engaged in the construction of an instrument which I believe may prove of sufficient importance, should I succeed in bringing it to practical perfection, to merit a visit to London. Determined to satisfy myself on the working of the machinery before I went any further, I prepared to make a model, and being unable to obtain the requisites at Heidelberg, I sought them at Frankfort. Whilst completing the model of my original plan, others on entirely fresh systems suggested themselves, and I have at length succeeded in combining the utile of each; but the mechanism requires a more delicate hand than mine to execute, or rather instruments which I do not possess. These I can readily have made for me in London, and, by the aid of a lathe, I shall be able to adapt the several parts, which I shall have made by different mechanicians for secrecy sake. Should I succeed it may be the means of putting some hundred pounds in my pocket. As it is a subject on which I was profoundly ignorant till my attention was casually attracted to it the other day, I do not know what others may have done in the same way; this can best be learned in London. You see I am very mysterious at present, and think it very prudent to continue so; nevertheless to you, dearest mother, if it were your wish, my plan and instrument should be explained now, though I think without better drawings than I could make you would scarcely comprehend me. As I do not wish my motives for revisiting London to be generally known, you had better, in mentioning it to any friends at Berne, state that private business requires my presence, and allow them to ascribe to modelling, or what they please, the sudden change of my plans."

This is a sample of the correspondence which goes on for a great many years. But besides these the collection comprises autograph letters from several very eminent persons, and many papers connected with the celebrated arbitration between himself and Sir Charles Wheatstone, and with the introduction of the telegraph and the formation of the Electric Telegraph Company, which was the first public company established for the purpose of telegraphic communication, and which opened its doors to the public on January 1, 1848, at which time about 1,500 miles of telegraph were in existence.

Life is proverbially uncertain, and I have therefore had very great pleasure in confiding these papers and documents to the care of the Institution of Electrical Engineers, and I thank you sincerely for the kind way in which you have accepted them.

I have now the pleasure of seconding the vote of thanks which has been proposed to Miss Alice Bolton, for her presentation to this Institution of the very artistic and excellent portrait of Mr. Jacob Brett which we see before us. Its artistic merits are very obvious to us all, and I can testify to its being an excellent likeness, as I have had the pleasure and privilege of knowing Mr. Brett for a great many years. It represents him not so much as he is to-day, but rather as he was some four or five years since, when the portrait was originally painted. Mr. Jacob Brett is now 83 years of age, and I grieve to say he lies on a sick bed through an accident which occurred to him some time ago in getting out of a vehicle; one of his legs was injured, and as the wound has reached the surface of the bone it is extremely difficult to heal. It is a great pleasure to me to know that Mr. Jacob Brett has been elected one of the very few honorary members of this Institution; for I feel that in conferring honour on Mr. Brett we have, perhaps unwittingly, conferred an honour upon ourselves.

I do not think it probable that many of those whom I see present with us this evening can be fully aware of the very important part which Mr. Jacob Brett and his brother, Mr. John Watkins Brett, have played in connection with the history of the introduction of the electric telegraph, and especially the Submarine Electric Telegraph, into the country and into the world. That connection dates back to a past generation, and is much deeper and more important than the world generally is aware of. His brother (Mr. J. W. Brett) and Mr. Brett were close friends and partners, and worked together in all their undertakings. His brother had a considerable fortune, which he was always ready to lavish on the advancement of submarine telegraphy. They commenced their public labours in 1845, and it is through their energy and devotion to the subject that we, as Englishmen, can claim for ourselves the distinction of having been the pioneers in the introduction of submarine telegraphy, as we can equally claim to have been the first nation to invent the electric telegraph and the first nation to

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introduce it into practical working. In order to be able to appreciate the early date at which they began their labours I would remind you that in 1837 Cooke and Wheatstone exhibited the private working of their telegraph from Euston to Camden Town; and the public then, for the first time, became aware of the possibility of the introduction of the electric telegraph as a factor in daily life. During the ensuing years, Sir W. Cooke, by his great business energy, succeeded in establishing telegraphic lines on many of our railways, as, for example, the Norwich and Yarmouth line, the Dalkey atmospheric line, the Northampton and Peterborough, the South Eastern, the Great Western, and others. But on January 1, 1845, an event occurred which startled the public mind, and contributed most powerfully to the advancement of the electric telegraph. On this date occurred the notorious case of the murder of a woman at Slough, by the Quaker, John Tawell, and his arrest was effected by the telegraph. After he had left by train for Paddington, a description of the murderer was forwarded by telegraph, and on his arrival he was seen to enter an omnibus. A detective mounted on the roof, and after watching him through several streets in the city, followed him into a small eating-house in an obscure and narrow alley, and seated himself opposite to him. Having satisfied himself by observation that he was in the presence of the right man, he suddenly accosted him with the question, "Haven't you just come from Slough?" Tawell's astonishment and his haggard looks at once betrayed his guilt, and he was eventually condemned and hanged for the crime. This episode occurred in 1845, and made a great impression on the public mind, and I have no doubt had its influence on the action of the two brothers Brett; for, on June 16th of that year, they registered "The General Oceanic Telegraph Company." I shall have to refer later on to this Company, but for the moment I only call attention to its date and to the fact that "The Electric Telegraph Company," the well-known pioneer telegraph company of Great Britain, was not registered until September 2nd in the same year.

On July 23, 1845, the two brothers laid before Sir Robert Peel and the Government their plans for uniting Dublin Castle with Downing-street, and also for a general system of oceanic and subterranean electric telegraphs, to include the United Kingdom and the Colonies, together with the establisnment of a system of postal telegraphs throughout Great Britain. That letter was printed in type by an electrical type machine patented by the Bretts, which was exhibited at 29, Parliament-street, and I well remember seeing it at that time. Copies of the letter were extensively distributed, and I believe that the instruments themselves are still in the possession of Mr. Jacob Brett. In the following year, 1846, they applied to the French Government for a concession for a cable to be laid at their own expense from England to France; and in 1847, this concession was granted to Messrs. Brett by His Majesty Louis Philippe, and in 1849 was further confirmed by Louis Napoleon, the President of the French Republic. They also applied in this year for a Belgian concession, which was granted to them in 1852.

In 1850 they laid down their first submarine line, the well-known single wire of gutta-percha, which was successfully completed on August 28th, just in time to save their concession. That wire, as we well know, was so slight that it failed almost immediately; but it was followed in 1851 by a permanent cable of a very different character, which, subject to repairs, was working in portions for 20 years or more, in fact no record exists of the date of renewal of the last remaining portions of it. This cable contained four conductors, and was armoured with stout iron wires in the usual manner; in fact, it formed the type for all future submarine cables. The success of this line enabled them to form in 1852, "The Submarine Telegraph Company," Mr. J. W. Brett himself being one of the Directors, which proved one of the most prosperous and successful of cable companies, and has only recently passed into the hands of the British Government.

In 1853 they laid the first Belgian line, and formed "The Mediterranean Electric Telegraph Company," followed by cables to Corsica, Sardinia, Algiers and many other places, while they were incessantly active in pushing forward their great scheme for a line of cables across the Mediterranean to Egypt, the Red Sea, India and Australia. Mr. J. W. Brett was also a Director of "The British and Irish Magnetic Telegraph Company," which in combination with others formed so powerful a rival to the old Electric Telegraph Company.

Now it must ever be a source of surprise that with such records as these the name of Brett should have been omitted or forgotten in 1866, when the somewhat lavish distribution of honours and titles was made in consideration of the splendid success of the Atlantic undertaking; and that surprise will not be diminished when I proceed to show you, that Mr. J. W. Brett was himself the originator, and one of the earliest and strongest supporters of that project.

I have said that on the 16th June, 1845, Mr. Jacob Brett had registered at the Joint Stock Companies' office "The General Oceanic Telegraph Company," the first telegraphic undertaking ever registered. I have seen the original certificate and receipt. But what is more curious is that even at that early date, the application goes on to say: "Object specified:—To form a connecting mode of communication by telegraphic means from the British Islands and across the Atlantic Ocean to Nova Scotia and the Canadas, the Colonies, and Continental Kingdoms." So that we are met by the extraordinary fact that the first telegraphic company ever registered in this country was formed, not with the object of erecting telegraphs on land, but for the purpose of laying a submarine cable across the Atlantic Ocean, and this at a period when the world at large had not even heard of submarine telegraphy. Later on in 1855 we find Mr. J. W. Brett associated with Peter Cooper, Cyrus Field, Dudley Field, Prof. Morse, and other prominent names, in founding the New York, Newfoundland and London Telegraph Company, and I have seen the receipt for the £3,000 which he contributed in 1856 as his share to the common fund. In October, 1856, we find the Memorandum of Association of "The Atlantic Telegraph Company," with a capital of £300,000, in 300 shares of £1,000 each; and again we find Mr. J. W. Brett's name at the head of the list with a subscription of £25,000, followed by the subscription of a like sum by Cyrus W. Field; and subsequently we find his name at the head of the list of Directors of the Atlantic Telegraph Company, which was at first unsuccessful.

It is most difficult to understand how such splendid services in the cause of Atlantic telegraphy could have gone unrequited and unnoticed. One can only conjecture that he must have impoverished his fortune by his too great liberality in his efforts to advance the cause of submarine telegraphy; so that when the final victory was won, and the hour of triumph and reward came, he was unable to take his place in front, and was left aside unnoticed and forgotten.

I feel very much gratified that this Institution should possess a portrait of the only survivor of the two brothers whose names will go down to posterity as those of the fathers of submarine telegraphy, and I have therefore the greatest pleasure in seconding the vote of thanks to Miss Alice Bolton. We also owe a debt of gratitude to her and her mother for the affectionate care with which they have assisted Mr. Brett during many long years of public neglect. As for Mr. Brett himself, I regret to say that he is in extremely straitened circumstances. He has for many years subsisted entirely on a pension of £100 a year, which was granted to him from the Civil Service fund, and he has no other means of subsistence. It will ever be regarded as a matter of wonder to future generations that the rulers and merchant princes of the Victorian era, who have derived such splendid benefits from submarine telegraphy, should have permitted two of the noblest of the pioneers of electrical science to thus pass away unnoticed and almost unknown.

Mr. Brett is, however, fortunately a man of happy and cheerful disposition, and feels amply repaid by the knowledge that the subject to which he devoted his early life has now become of almost infinite importance to mankind; that by day and night myriads of signals are ceaselessly flashing through every ocean, and bearing their priceless messages of love or of commerce, of peace or of war. It is a pleasure to feel that when he shall be called away to his last rest, he will be sustained by the proud consciousness that he has been enabled to confer greater benefits on his country and on the world than any other man now living.

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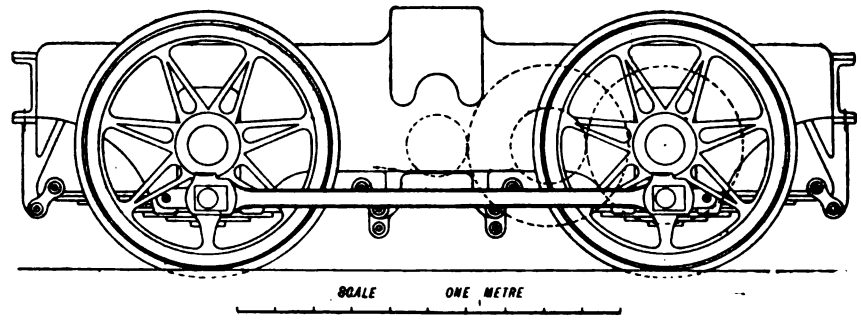
THE HAGUE AND SCHEVENINGEN ELECTRIC TRAMWAY.

Not contenting themselves with the natural facilities for traffic afforded by level roads and numerous canals, and a good railway service, the Dutch are well to the front in their very extensive use of tramways. The tram service in the larger towns is excellent, the fares are very moderate when compared with general prices and the limited buying power of Dutch money. An extensive use is made of steam tramways, which are wisely kept for inter-urban traffic; and, though running on the same lines and in connection with the horse trams, do not pass through the busy streets. The steam tram line from Haarlem to the Hague, passing by Leyden, runs in direct competition with the railway, canal, and road, but does an excellent business, stopping to pick up or set down passengers at or between the villages, and carrying goods as well as two or three cars of passengers. The nature of this traffic is well worth the attention of those who wish to introduce electric tram lines in this country.

During a recent visit to the Hague, which is well served by both horse and steam trams, we noticed some large and substantially-built double bogie cars, the wheels being coupled, but destitute of any visible means of propulsion. So little fuss was made about them that for a day or two we thought they were driven by compressed air; but on closer inspection it was evident from the starting gear that they were provided with accumulators and motors, though both of these were invisible. Finding that no branch of the line went near the electric light station (*The Electrician*, Vol. XXVII., p. 577), and experiencing some difficulty in expressing in the vernacular a wish to visit the charging station, we mounted a car and kept a look-out for it. The route lay to Scheveningen, the fashionable watering-place, about two miles distant. To the exorbitant hotel charges at Scheveningen is due the facilities for traffic from the Hague. A horse tram line runs along one side of the beautiful avenue connecting the two places, a steam tram line in connection with the State railways runs by a rather more circuitous route, and between the two, among the sandhills, and with gradients of 1 in 20, and curves of 14 metres radius, a remarkably smooth running line is laid for the electric tram. In the town, a moderate pace is allowed, but when clear of the suburbs a speed of 20 kilometres an hour is maintained, and an occasional spurt at 30 kilometres when the road is clear and the gradient favourable.



Elevation of Bogie.

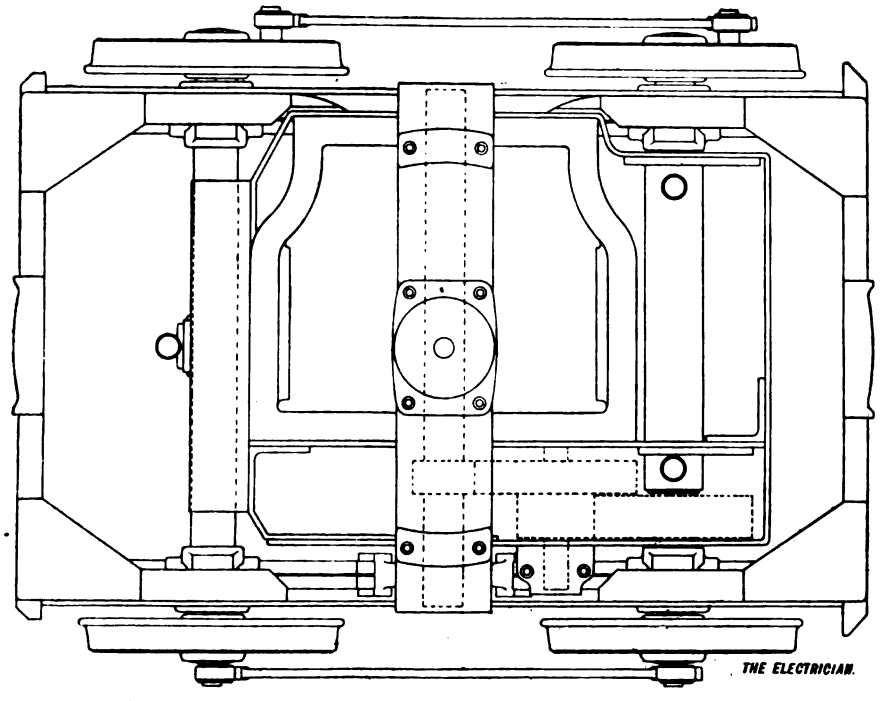


FIG. 1.--Plan of Bogie, showing Inner Frame and Outline of Motor.

Among the dunes behind the Scheveningen Kurhaus a large station has been erected, consisting of an engine-room, charging shed, engineers' workshop driven by a motor, and a battery room, besides offices and dwelling-house. The workshop motor is worked from a battery which is also used for running 10 arc lamps. Three Silvertown dynamos, driven from countershafting, are run from two condensing steam engines, each indicating 210 H.P. Condensing water is supplied through a syphon from the canal 1,200 metres distant. A "Swiss" cross-bar plug board is provided, by which any dynamo can be connected to any charging circuit. An output of 60 amperes at 500 volts can be generated, the usual charging current on each circuit is 19 amperes at 450 volts, and this is controlled by a number of ammeters and hand resistance-regulators attached to the switchboard. The use of points for directing the cars into the charging shed, repairing shop, or the car shed, is avoided by a rolling transfer bridge; and a bridge in the repairing shop, provided with screwjacks,

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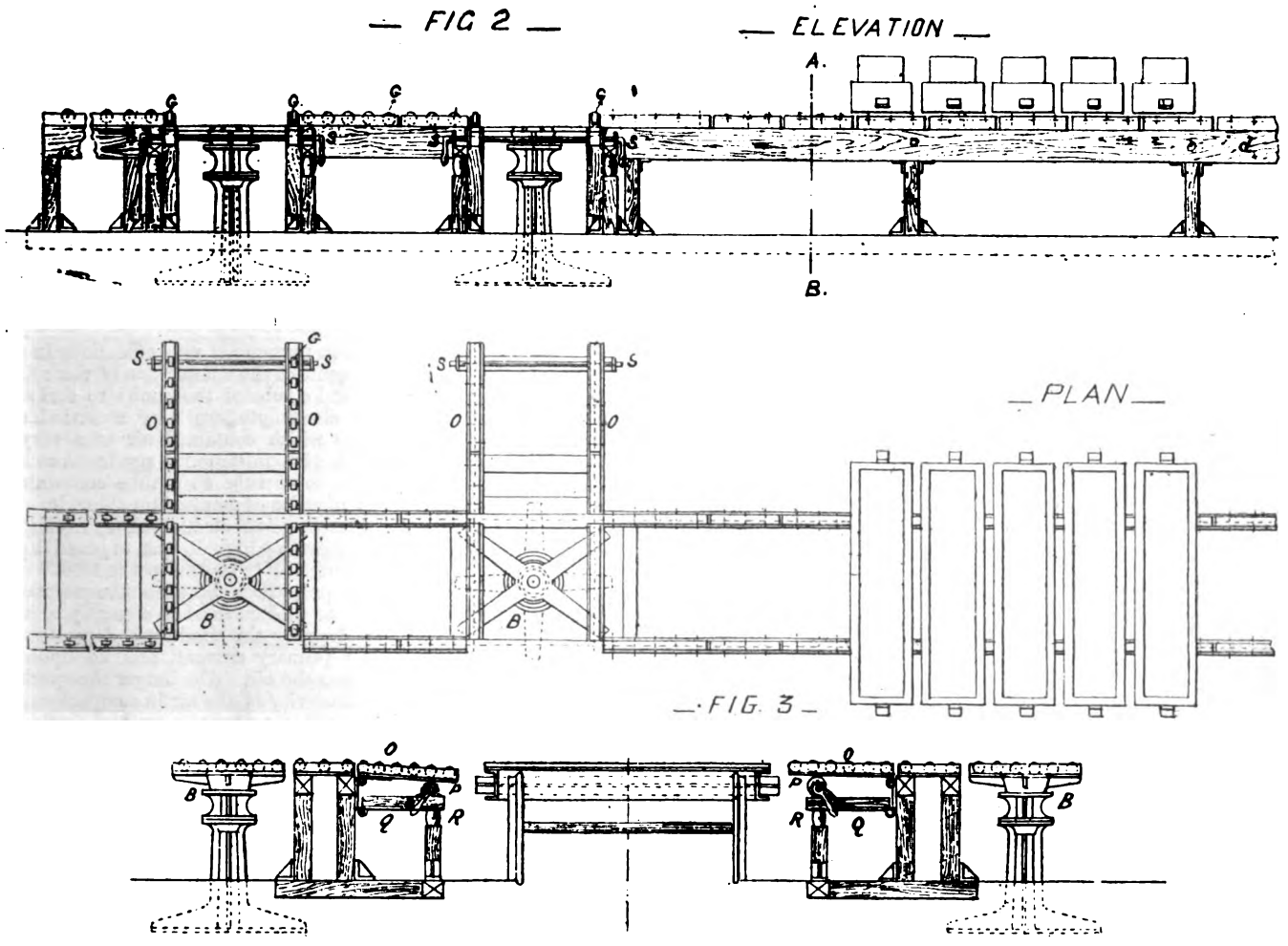
and running over a long pit, enables the cars to be easily removed from the bogies.

The plant, as arranged by the makers, gave a good deal of trouble. Chain gear was used on the motors, and this was both noisy and subject to wear. When the management of the line was undertaken by Herr P. van Vloten, he designed the excellent system of changing and charging the batteries, and entirely re-arranged the motor. It was necessary to use the old motors and the outer bogies, but the gear and inner bogie were entirely reconstructed. Fig. 1 shows an elevation, and a plan of the present arrangement. An intermediate gear is used, and this, together with the driving wheel, is of cast steel. The pinion on the motor is of a pattern which has been re-invented several times. It consists of a number of discs of sheet steel separated by leather, the whole mounted on a hexagonal shaft and firmly screwed up. No signs of grooving were visible on the intermediate wheel. A pinion was shown us which had run some 6,000 kilometres; it was considerably worn, but by no means worn out. A new one can be refitted in a few minutes at no great cost. The gear is a very close fit for the inner bogie, owing to the reconstruction; a clearance of only two millimetres being possible at one point. The weight of the car is taken by the centre of the outer bogie, and is transmitted to the axles by three rubber springs, as shown in plan. The tractive force is transmitted from the motor to the inner frame by the bearings, and from this by short links to the outer bogie. These links allow of some vertical play between the two frames. The bearings of the axles have a vertical play in the outer bogie, as is shown in elevation.

The most remarkable feature at the station is the method of handling the accumulators for charging. A good deal of ground space is occupied, it is true; but such a station would generally be built outside a town, as in the present case. Two lines run the whole length of the shed, and examining pits are provided between the rails. On each side of the lines are benches or tables, 26 metres long, and on these the accumulators are charged in series. A car, containing batteries which require charging, is run to the end of the shed, and doors at the sides of the body are opened. These give access to the accumulators, which are arranged under the seats in eight sets, each weighing 500 kilogrammes. Each set is contained in a case, which is provided with contact strips, automatically making connection when run into place in the car. When a set of batteries is to be withdrawn, the car is placed so that a hinged bracket O (Figs. 2 and 3) is presented for their reception. The batteries are run out on to this bracket, which is provided with rollers G. When the battery is pulled on to the bracket, an eccentric P below the shelf is turned by a lever S, and thus the bracket is raised on its hinge, and the battery is run on further to a turn-table B. The eccentric is mounted on a lower hinged frame Q. A rubber buffer R is arranged underneath, to prevent any jar. A quarter turn being given, the set of batteries is run forward on to the charging bench *d*, rollers being provided throughout its length. The details for ensuring the insulation of the batteries and their electrical contacts with the charging current are very ingenious, and no mistake can be made in the connections. The eight sets of batteries can be run out simultaneously on to eight brackets and turn-tables, those already on the bench are pushed forward from time to time to make room, the charging going on all the time, all the sets being in series. The batteries can be removed from the car in about two minutes. The empty car is then run back towards the door of the charging shed, and at the other end of the charging bench a similar arrangement of turn-tables and hinged brackets is provided. Matters are so arranged that by the time a set of batteries has travelled the whole length of the bench it is fully charged. Two minutes suffices for running them into the cars, and five minutes after entering the



FIGS. 2 and 3. – Details of Charging Bench, Brackets and Turn-tables for Handling Accumulators.

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shed a car can be run out again with a fresh set of accumulators.

Each car contains 4,000 kilogrammes of Julien accumulators. The plates are very thin, and are very close together. Thin ebonite boxes are used. The line as reconstructed had been running for some four or five months on the occasion of our visit without any perceptible deterioration of the batteries; but some changes were in contemplation, and it is proposed to manufacture a battery for the purpose on the premises.

The line outside the Hague is excellently laid on transverse sleepers; the motion is perfectly smooth and noiseless. The starting and change of speed is controlled by a resistance switch, combined with a commutator. A mechanical locking device is arranged, so that the commutator cannot be moved until the resistance switch, after putting in all the resistance, has cut off the current. The commutator enables the accumulators to be placed all in series for high speed, or in two sets in parallel for slow speed. Carbon brushes are used. Six cars were running last season, each being capable of seating 68 passengers. The length over all of the car is 10 metres. They were built by Beynes, of Haarlem, and weigh 16,000 kilos. A run of 70 kilometres—that is, seven double journeys—is made with one charge. The service is used only during the Scheveningen season, and the plant for charging and general accommodation is sufficient for a considerable increase of traffic. The cost of the service could not, therefore, be compared with other systems, but the engineering details are none the less interesting; and as the cars are run by the Haagsche Tramweg Maatschappij they will be able to compare their cost with the other portions of their service, and it is probable that some publication of the figures may be made before long.

ON THE DISCHARGE OF ELECTRICITY THROUGH EXHAUSTED TUBES WITHOUT ELECTRODES.*

BY J. J. THOMSON, M.A., F.R.S.

(Continued from page 43.)

Screening Effects Due to the Currents in the Tubes.

Before describing some further experiments on this shielding effect it will be useful to consider the means by which it is brought about. Let us suppose we have a vertical plate made of conducting material, and to the right of the plate a region, A, which it shields. This region has to be shielded from tubes of electrostatic induction coming from the left which have to pass through the shield before reaching A, and from tubes coming from the right which have to pass through A before reaching the field. The action of the shield in the first case is very simple, for when a tube gets inside a conductor it at once attempts to contract to molecular dimensions, and after a time proportional to the specific resistance of the conductor it succeeds in doing so. Thus if the shield is made of a good conductor the tubes of electrostatic induction will be transformed into molecular tubes before they have time to get through; so that the shield will protect A from all tubes which have to go through it. The way the shield destroys or rather neutralises the effect of the tubes coming from the right is somewhat different: when a positive tube reaches the shield a negative one emerges from it, travelling at right angles to itself in the opposite direction to the incident tube; thus when the first few tubes reach the shield from the right they will produce a supply of negative ones, and the presence of these negative tubes at A concurrently with the positive ones which continue to arrive there will weaken the field to a greater and greater extent as A approaches the shield. At the surface of the shield itself the neutralisation will be complete. A dielectric whose specific inductive capacity is greater than usual will behave in a similar way to a metal plate, but to a smaller extent. It will emit tubes of the opposite sign, but not so numerous as those incident upon it. Thus a metal plate, or even one made of a dielectric of considerable specific inductive capacity, will reduce very considerably the tangential electromotive force on either side it.

I have made several experiments in which this effect was very strikingly shown. In one of these two square discharge-tubes of equal cross-section placed near and parallel to each other were connected by a cross tube, so that the pressure was the same in both tubes; a fine wire passed round the inside of one of the tubes, its ends being connected together so that it formed a closed circuit, the other tube contained nothing but air at a low pressure. When this double tube was placed outside the primary the discharge went, at the passage of each spark, through the tube without a wire, while the tube containing the wire remained quite dark. A similar experiment was tried by taking a cylindrical tube and suspending in it a metal ring coaxial with the tube; in this case it was easy to adjust the spark-length so that no discharge passed through the tube when the primary was placed round it at the level of the ring, while a discharge passed as soon as the primary was moved above or below the ring.

Another very convenient tube for showing this effect is the one with the hollow down the middle, Fig. 11; when this is pumped so that discharges can pass through the outer tube the spark-length can be adjusted so that the discharge stops immediately when a metal tube, a test-tube containing a strong solution of an electrolyte, or a tube containing air at a pressure at which it is electrically very weak, is placed in the central opening. The discharge is renewed again as soon as the tubes are removed. On one occasion, when the large tube was in a peculiarly sensitive state, I was able to see distinctly the diminution produced by a dielectric in the electromotive intensity parallel to its surface. The discharge stopped as soon as a stick of sulphur or a glass rod sufficiently large almost to fill the opening was inserted, and was renewed again as soon as these were withdrawn. It requires, however, the large tube to be in an extremely sensitive state for the effect produced by a dielectric to be apparent, and I have only on one occasion succeeded in getting the tube into this condition. The effect on that occasion, however, was so definite and regular that I have no doubt as to the existence of the screening effect due to the dielectric.

When the tube is of average sensitiveness dielectrics do not produce any appreciable effect, nor can the influence of even comparatively so good a conductor as distilled water be detected, and it is not until after the addition of a considerable quantity, 10 to 20 per cent., of sulphuric acid or ammonium chloride, that the insertion or withdrawal of the tube stops or starts the discharge.

A tube containing air at a low pressure is very efficacious in stopping the discharge, and the result of the comparison of the relative effects of an exhausted tube and a tube of the same size and shape containing a solution of an electrolyte are very remarkable. I found that an exhausted tube which contained air at a very low pressure (less than one-tenth of a millimetre) produced as much effect on the discharge in the outer tube as a tube containing at least 50,000 times as many molecules of ammonium chloride. This would be expressed in the language of electrolysis by saying that under the electromotive intensity to which it was exposed in this experiment the molecular conductivity of the gas is 50,000 times that of the electrolyte. The proportion between the number of air molecules and the number of molecules of an electrolyte, which produces an equal effect in stopping the discharge, depends upon the length of spark in the primary current, and so upon the electromotive force acting upon the air. The longer the spark the greater is the molecular conductivity of the air in comparison with that of the electrolyte. This indicates that the conduction through the air does not follow Ohm's law. This is what we should expect, as under large electromotive forces more molecules are split up and take part in the conduction of the electricity. This great conductivity of rarefied gases in those cases where the electricity has not to pass from metal, &c., into the gas are in striking contrast with the infinitesimally small values for the same property which are deduced from experiments on tubes with electrodes.

I was first led to suspect this high conductivity for rarefied gases by observing the appearance presented by the ring-discharge in bulbs; the ring, unless the pressure is exceedingly low, ceases at a distance of little more than 1 centim. from the surface of the bulb, this thickness of conducting gas being sufficient to screen off the electromotive intensity from the interior. From experiments which I had made on the screening effect of electrolytes (*Proc.* Roy. Soc. XLV., p. 269), I knew that it would require a very strong solution of an electrolyte to produce screening comparable with this. To compare the screening effects more directly than by the method just described I tried the following experiment:—The discharge-tube (Fig. 11) was pumped until the discharge passed through it very freely. An exhausted tube was then pushed down the central opening; it remained quite free from any visible discharge. The primary was now wound round a cylinder of the same diameter as the discharge-tube of Fig. 11, and this cylinder was filled with distilled water. When the tube, which had previously remained dark when placed in the exhausted discharge-tube, was immersed in the water, a brilliant discharge took place in it; and it was necessary to add about 25 per cent. of sulphuric acid to the water before the shielding effect of the mixture was sufficient to keep the tube dark. This experiment shows, perhaps, even more directly than the other the great conductivity of a rarefied gas under large electromotive forces when nothing but the gas is in the way of the passage of the current.

An experiment made in this connection illustrates the remark made before as to the large effects produced by discharges through

* Abstract from the *Phil. Mag.*, October, 1891.

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the gas which are not accompanied by luminosity. A bulb, A, was fused into a tube, B, which was surrounded by the primary coil C, D. B was exhausted and then sealed off, while A was left connected to the pump. When A was at atmospheric pressure a bright discharge took place in B outside A; on pumping A a stage was reached in which no discharge could be seen in either A or B. On letting air into A the discharge appeared again in B; on pumping A still further a discharge appeared in A, but not in B. The appearance presented by the discharge round the bulb A (filled in this case with air at high pressure) is very remarkable. At the highest pressure at which the discharge passed it took the form of

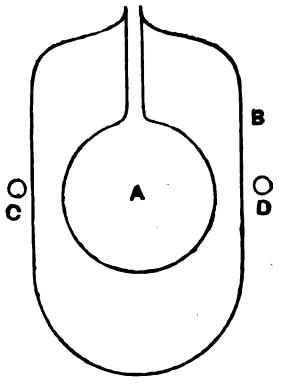

Fig. 13.

a thin ring round the middle of A; as the pressure got lower and lower the discharge broadened out, and at very low pressures formed for the greater part of its course two separate rings which ran together in the space between one side of the sphere and the tube.

(*To be continued.*)

DESCRIPTION OF THE STANDARD VOLT AND AMPERE-METER USED AT THE FERRY WORKS, THAMES DITTON.*

BY CAPTAIN H. R. SANKEY AND F. V. ANDERSEN.

1. Introductory.

It is well known to many electricians that Messrs. Willans and Robinson have established at their works at Thames Ditton a complete arrangement for measuring accurately the steam consumption of their engines. To obtain the efficiency of combined sets of engines and dynamos, measurements must, of course, also be made of the electric current and pressure, and it was thought that even the best ammeters and voltmeters in the market could not be relied upon to give the same degree of accuracy as was obtained in the steam-consumption measurements. At any rate, all such instruments laboured under the disadvantage that they were calibrated elsewhere, so that the results were dependent upon other people's measurements to a degree which was thought to be undesirable.

After a series of investigations—commenced as early as 1887—into the question of the class of apparatus which would be most likely to give satisfactory results under the special circumstances, a scheme was drawn up in 1889 for a complete apparatus for measuring currents, differences of potential, and resistances, and the various instruments were designed and ordered. It was not, however, until the beginning of the present year that time and opportunity were found to have the apparatus put to practical use, various additions and improvements being introduced as the work proceeded. It is well to mention at once that the results obtained with this apparatus are in practical agreement with those obtained with the Siemens dynamometers previously in use.

As will be seen in the sequel, no new principles have been introduced in electrical measurements with the present apparatus. It was thought, however, that a complete set of workshop instruments, fulfilling the conditions for high accuracy, and yet possessing the simplicity required for everyday use in an engineer's shop, would be found of sufficient interest to electrical engineers to justify a short account of it being brought before the Institution.

The more important conditions imposed in designing the apparatus were that—

1. All measurements made must be capable of verification at any time by direct comparison of certain resistance coils with a standard ohm, and of a constant potential difference with a standard cell; and that the arrangements should allow of these comparisons being made quickly for the satisfaction of those interested in the accuracy of the measurements.

2. Volts and amperes must be indicated by direct deflection on a scale, and no balancing operation be required from the observer by torsion arrangements or otherwise; and the value of the readings must not be influenced by the working of dynamos or the moving of large masses of iron within a few yards distance.

3. The ammeter as well as the voltmeter must be left in circuit permanently during trials of any desired length.

4. The errors to which the measurements are liable should not exceed one-fifth per cent.

5. The range such as to allow of measurements being made of pressure from a thousandth part of a volt to 700 volts, and of current from a fortieth of an ampere to 1,100 amperes.

2. Apparatus Required.

The complete apparatus comprises the following :—

I. *For Measuring Amperes.*

One D'Arsonval galvanometer.
One high-resistance box, adjustable by the unit, for use in series with galvanometer.
One rheostat of platinoid strips for carrying the main current (called resistance B).

II. *For Measuring Volts.*

One D'Arsonval galvanometer.
One high-resistance box, adjustable as above, for use in series with galvanometer. A Wheatstone bridge box is used for this purpose.
Three potentiometer rheostats, 250 ohms each, made of platinoid wire on screwed slate rods, carrying capacity up to 1 ampere.

II.—*For Calibration.*

One Clark standard cell containing two elements.
One standard ohm.
One standard rheostat of five platinoid strips, arranged for coupling in parallel or series, each strip capable of carrying 10 amperes (called resistance A).
One mercury rheostat, capacity 50 amperes.
One secondary battery, three large cells (15 L. E.P.S.).
One key with double set of contacts, for use with standard cell.
One resistance coil, 10,000 ohms, for use with same.
Two $\frac{1}{9}$ shunts for galvanometers.

IV.—*General.*

Leclanché cells for bridge test, keys, ebonite pillars for connections, &c.

The method of using the apparatus for actual measurements will first be described, after which the calibration of the galvanometers and the verification of the various resistances will be discussed.

3. Measuring Amperes.

The apparatus used for this purpose is shown on Fig. 1* with the connections in dotted lines. On the same figure is drawn the voltmeter arrangement, in order to give the general arrangement of the

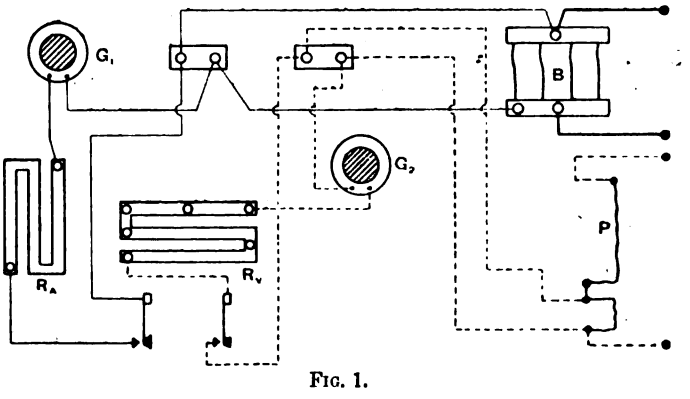

Fig. 1.

whole set of instruments; the circuits of the voltmeter arrangement are in black. It will be seen on Fig. 1 that for current measurements the method of measuring the fall of potential across a known resistance has been adopted. The measurement of this resistance—*i.e.*, the resistance of rheostat B, Fig. 2 and Fig. 1, which, of course,

* Paper read before the Institution of Electrical Engineers.

* We have taken the liberty of renumbering the figures in the order in which they are referred to.—Ed. *E.*

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must be made with great accuracy—could not be taken satisfactorily by a Wheatstone bridge, owing to its small value (about ·001 ohm); the method adopted for this purpose will be described further on.

The scale of the D'Arsonval galvanometer, G_1, has, in addition to the ordinary millimetre scale, another scale graduated to read from 0 to 1,100 amperes, on which the divisions are proportional to the corresponding currents through the galvanometer, the relation or constant connecting the deflections with this current being known from the calibration of the galvanometer.

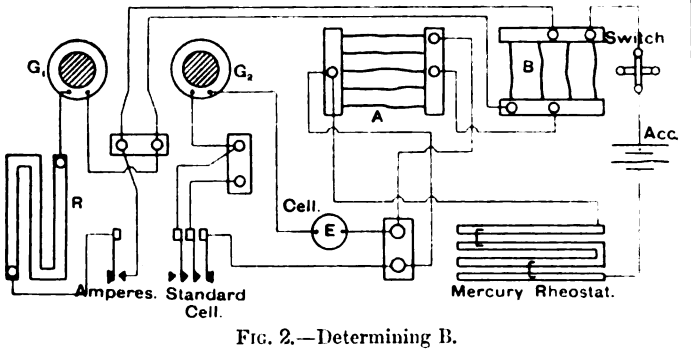

FIG. 2.—Determining B.

By modifying the resistance, R_A, used in series with the galvanometer, the constant of the ammeter can be modified to suit the number of amperes to be measured. If

k = current through G per unit deflection on ampere scale;
K = ,, ,, B ,, ,, ,, ,,
B = ohms resistance of B;
G = ,, ,, of galvanometer;
R_A = ,, ,, in series with galvanometer:

then for any deflection, D, on the ampere scale $(G+R)\,k\,D = K\,D\,B$;

and so $$R_A = K\,B/k - G \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

In the present case we have,

B = ·0010882 legal ohms at standard temperature, 17°C.
G = 429 ,, ,, ,, ,,
$k = \cdot 06 \times 10^{-6}$ amperes;

and, therefore, the resistance R to be used in series with the galvanometer to obtain different ammeter constants = K × 18,137 − 429 legal ohms.

Table I. gives the constants in use, and the corresponding values of R.

Table I.

Ammeter constant K.	R_A in legal ohms.	Correction legal ω per °C of rise in B.	Remarks.
1	17,708	4·17 + γ	Rise in B.
0·5	8,639	2·09 + γ	$= C^2 \times 2 \times 10^{-5}$ °C.
0·1	1,385	0·417 + γ	γ = 1·66 (17 − t).
0·025	24	0·0417 + γ	t = temp. of G in °C.

The following are the corrections for temperature which must be made in R in order to get the accuracy desired:—

(1.) For the galvanometer, at the rate of 1·66 ohms per degree Centigrade variation from the standard temperature—in this case 17° C.

(2.) For the rise in B due to the current at the rate of ·023 per cent. per degree Centigrade, the amount of resistance per degree is given in the third column of the table; and the constant for calculating, from the current, the rise of temperature in B, as determined by experiment, is given in the fourth column.

When the main rheostat, B, is made from the same metal and placed in the same room as the resistance box R_A, the periodic temperature variations in the atmosphere do not affect the measurements of the current through the increase of the resistances of these two instruments, as the increase in one balances that in the other.

For ordinary work the readings on the scale are amply accurate, as they can be depended upon to be within ·3 per cent. of error.

For very accurate trials, however, the scale is used only to ensure the practical steadiness of the load, and for taking readings at short intervals in order to obtain the mean reading. The current corresponding to this mean reading is then determined by direct comparison with the standard ohm and cell.

This determination of the current is made by substituting in the galvanometer circuit an E.M.F. equal to that of the standard cell for the potential difference on the terminals of B, and then, by shunting the galvanometer and adjusting R_A, reproducing the deflection in question. If, then,

C = the current to be determined;
G = the resistance of the galvanometer;
R_1 = the resistance in series with G when standard cell is in circuit;
R_A = the resistance in series with G when B is in circuit;
e = the E.M.F. of standard cell;

and if the shunt is of a multiplying power = m: then

$$C = \frac{R+G}{m R_A + G}\,\frac{e}{B} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

(To be continued.)

DINNER OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

The third annual dinner of the Institution of Electrical Engineers was held at the Criterion, Piccadilly, on Friday last; the President (Prof. Crookes) in the chair. Amongst those present were:—Sir George Gabriel Stokes, Bart., M.P.; Mr. George Berkly (President of the Institution of Civil Engineers); Mr. Latimer Clark (past President), Mr. W. H. Preece (past President), Sir Frederick Abel, K.C.B.; Prof. W. Grylls Adams, Sir John Pender, K.C.M.G.; Sir Benjamin Baker, K.C.M.G.; Sir Thomas Blomefield, Bart.; Prof. D. E. Hughes, Dr. Fleming, Captain Wharton, R.N.; Major Cardew, R.E.; Mr. Edward Graves, Colonel W. Haywood, Major G. W. Addison, R.E.; Mr. C. E. Spagnoletti, Major-General Webber, Colonel R. Raynsford Jackson, Sir David Salomons, Bart., &c., &c.

The PRESIDENT announced that they had to regret the absence of several guests. The Postmaster-General had accepted an invitation, but was at the last moment obliged to decline, not being sufficiently well. Amongst others who expressed their regret at not being able to join them were Mr. Tomlinson (the President of the Institution of Mechanical Engineers), Mr. Giles, M.P. (Vice-President of the Institution of Civil Engineers), Dr. Pool (Hon. Sec. of the Institution of Civil Engineers), and Dr. John Hopkinson.

After the usual loyal toasts, the PRESIDENT rose and proposed the toast of "Electricity in relation to Science." He said:—We have happily outgrown the preposterous notion that research in any department of science is mere waste of time. It is now generally admitted that pure science, irrespective of practical applications, benefits both the investigator himself and greatly enriches the community. "It blesseth him that gives and him that takes." Between the frog's leg quivering on Galvani's work table, and the successful telegraph or telephone there exists a direct affiliation. Without the one we could not have the other. We know little as yet concerning the mighty agency of electricity. "Substantialists" tell us it is a kind of matter. Others view it, not as matter, but as a form of energy. Others, again, reject both these views. Prof. Lodge considers it "a form or rather a mode of manifestation of the ether." Mr. Nikola Tesla demurs to the view of Prof. Lodge, but thinks that "nothing stands in the way of our calling electricity ether associated with matter, or bound ether." High authorities cannot even yet agree whether we have one electricity or two opposite electricities. The only way to tackle the difficulty is to persevere in experiment and observation. If we never learn what electricity is, if, like life or like matter, it should remain an unknown quantity, we shall assuredly discover more about its attributes and its functions. The light which the study of electricity throws upon a variety of chemical phenomena, witnessed alike in our little laboratories and in the vast laboratories of the earth and the sun, cannot be overlooked. The old electro-chemical theory of Berzelius is superseded, and a new and wider theory is opening out. The facts of electrolysis are by no means either completely detected or co-ordinated. They point to the great probability that electricity is atomic, that an electrical atom is as definite a quantity as a chemical atom. The electrical attraction between two chemical atoms being a million times greater than gravitational attraction is probably the force with which chemistry is most deeply concerned. It has been computed that in a single cubic foot of the ether which fills all space there are locked up 10,000 foot-tons of energy which have hitherto escaped notice. To unlock this boundless store and subdue it to the service of man is a task which awaits the electrician of the future. The latest researches give well-founded hopes that this vast storehouse of power is not hopelessly inaccessible. Up to the present time we have been acquainted with only a very narrow range of ethereal vibrations, from extreme red on the one side to ultra-violet on the other. Within this comparatively limited range of ethereal vibrations, and the equally narrow range of sound vibrations, we have been hitherto limited to receive and communicate all the knowledge which we share with other rational beings. Whether vibrations of the ether, slower than those which affect us as light, may not be constantly at work around us, we have until lately never seriously enquired. But the researches of Hertz in Germany, and of Lodge in England, give us an almost infinite range of ethereal vibrations or electrical rays from wave-lengths of thousands of miles down to a few feet. Here is unfolded to us a new and astonishing

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universe—one which it is hard to conceive should be powerless to transmit and impart intelligence. Experimentalists are reducing the wave-lengths of the electrical rays. With every diminution in size of the apparatus the wave-lengths get shorter; and could we construct Leyden jars of molecular dimensions, the rays might fall within the narrow limits of visibility. We do not yet know how the molecule could be got to act as a Leyden jar; yet it is not improbable that the discontinuous phosphorescent light emitted from certain of the rare earths, when excited by a high-tension current in a high vacuum, is really an artificial production of these electrical rays, sufficiently short to affect our organs of sight. If such a light could be produced more easily and more regularly, it would be far more economical than light from a flame or from the arc, as very little of the energy in play is expended in the form of heat rays. Of such production of light, nature supplies us with examples in the glow-worm and the fire-flies. Their light, though sufficiently energetic to be seen at a considerable distance, is accompanied by no liberation of heat capable of detection by our most delicate instruments. By means of currents alternating with very high frequency Mr. Nikola Tesla has succeeded in passing by electrostatic induction through the glass of a lamp energy sufficient to keep a filament in a state of incandescence without the use of connecting wires. The extent to which this method of illumination may be practically available experiment alone can decide. In any case, our insight into the possibilities of static electricity has been extended, and the ordinary electric machine will cease to be regarded as a mere toy. Alternating currents have, at the best, a rather doubtful reputation. But it follows from Tesla's researches that as the rapidity of the alternation increases they become not more dangerous, but less so. It further appears that a true flame can now be produced without chemical aid—a flame which yields light and heat without the consumption of material and without any chemical process. To this end we require improved methods for producing excessively frequent alternations and enormous potentials. Shall we be able to obtain these by tapping the ether? If so, we may view the prospective exhaustion of our coal fields with indifference. We shall at once solve the smoke question, and thus dissolve all possible coal rings. Electricity seems destined to annex the whole field, not merely of optics, but probably also of thermotics. Rays of light will not pass through a wall, nor, as we know only too well, through a dense fog. But electrical rays of a foot or two wave-length, of which we have spoken, will easily pierce such media, which for them will be transparent. Another tempting field for research, scarcely yet attacked by pioneers, awaits exploration. I allude to the mutual action of electricity and life. No sound man of science endorses the assertion that "electricity is life," nor can we even venture to speak of life as one of the varieties or manifestations of energy. Nevertheless, electricity has an important influence upon vital phenomena, and is in turn set in action by the living being—animal or vegetable. In the study of such facts and such relations the scientific electrician has before him an almost infinite field of inquiry. The slower vibrations to which I have referred reveal the bewildering possibility of telegraphy without wires, posts, cables, or any of our present costly appliances. It is vain to attempt to picture the marvels of the future. Progress, as Dean Swift observed, may be too fast for endurance. Sufficient for this generation are the wonders thereof (applause). I have the pleasure to associate this toast with the name of Sir George Stokes. We expected that Sir Wm. Thomson, the President of the Royal Society, would have been here; but in his absence we could not have a better representative of science in all its branches, electrical and every other science, than Sir George Stokes.

Sir GEORGE STOKES, in responding, said among the various individual sciences there was hardly any to compare with electricity in two respects, viz., in the multitudinous points of contact which it had with other sciences, apparently remote, and in the remarkable way in which abstract theoretical investigations found their application in actual practice. It was very closely connected with chemistry. The discovery of Faraday of the law of electro-chemical equivalents showed how close that relationship must be. What was an electric current? They did not know. Whatever it was, it must, however, be in some way or other very closely associated with chemical union and decomposition. Then, again, to take light: they knew in some respects a great deal more about light than they did about electricity. About 39 years ago he happened to be sitting at dinner during a meeting of the British Association beside the illustrious Faraday; and he said to Faraday that "he thought a great step would be made if we could say as much of electricity as we could say of light, when we said that it consists of vibrations," and Faraday said to him that "he thought that we were yet a long way off from that." Nevertheless, the connection between light and electricity had been rendered much more close by recent researches; first came that great discovery of Clark Maxwell's, and then the remarkable investigation of Hertz.

Mr. C. E. SPAGNOLETTI, in giving "Electricity in its Practical Application," treated upon the usefulness of electricity and its convenience to every class of the community in all quarters of the globe.

Sir JOHN PENDER replied. He could not, he said, give them any information from the high scientific point of view, but he could say something in reference to the practical application of electricity. He had been for the last 30 years more or less associated with this important want. When he first had to do with submarine telegraphy there was not two thousand miles of cable laid. Now there was over 130,000 miles of cable laid, representing a capital of over 40 millions; and that capital had been got from the public, and a very large proportion of it was paying a healthy dividend. There was also about two million miles of land lines. He did not touch upon them so much because he was not so closely associated with them, although he was one of the first directors of the land line system in this country. Amongst those associated with him in the earlier days of electricity was Mr. Latimer Clark, who continued to be their practical adviser on all the cable companies with which he was connected. Then his friend Sir William Thomson had a lively appreciation of what science could do if properly handled by practical men; and it was through Sir William that he took up submarine telegraphy, which now occupied a position second to none in the world. He believed it had done more to promote human progress in the last quarter of a century than any other thing that had been brought forward. They had now through the application of Dr. Muirhead's duplex system to their telegraphs practically doubled the carrying power of their cables; in other words, if they had to lay down to-day the cables necessary to carry on the cable traffic without the duplex system, it would add at least 20 millions more to their capital. That duplex system applied to submarine telegraphy had proved an enormous success in the hands of practical men. With reference to the electric light he remembered looking at it as a laboratory experiment; and then for nine years he saw an enormous amount of money spent foolishly in connection with it. He said to two or three of his friends, "We ought to deal with this electric light, we have dealt successfully with telegraphs; let us endeavour to bring it into a practical form." He thought they had been successful in doing that. He was proud to say that the electric light was now upon a basis which he had not the slightest hesitation in saying must be a very great practical improvement. When he first took up telegraphs he did not know half-a-dozen men who called themselves electrical engineers. That was only a quarter of a century ago; and he believed now that the Institution of Electrical Engineers mustered something like 2,000 members. Surely that marked enormously the success of electrical science, coupled as it had been with commercial energy and commercial foresight. There was a great deal to be done yet in the electrical field. He did not know any field so broad or more encouraging for young engineers as electricity. Representing as he did telegraphs and electric lighting companies, if there was any man who could bring something to him which would enable him to add 1 per cent. to the dividend they were now paying, he should be only too glad to treat with him. The President had said that there was a time coming when possibly we could do without wires and other costly appliances. He wished that that good time would come before he died, for at present the power they used was enormously expensive. If they could only reduce the expense in some degree there was no conception as to the extent to which it could be applied. With regard to the electric light, for instance, there were but some 300,000 lights in London, and if they had three million lights they would not be too many. It was for the electrical engineers to give the capitalists something to turn to practical account, and it would be rapidly taken up (loud cheers).

Mr. W. H. PREECE next gave "Our Guests," coupled with the name of Mr. George Berkly, the President of the Institution of Civil Engineers, who responded.

In proposing "The Institution of Electrical Engineers," Sir GEORGE GABRIEL STOKES said it was remarkable how little they knew of the real nature of electricity in itself, and yet how much they had applied it for practical purposes. They could hardly help believing that if they attained to a more intimate knowledge of what its real nature was applications would spring up of which at present they had little idea. Their President's discovery of the radiometer gave them a clear conception of the molecular constituents of bodies, and especially gases. They appeared to be on the brink of some great discovery, and this ought to make them feel an interest in their work.

The PRESIDENT, in reply, said that he felt perplexed how best to respond to the very kind way in which Sir George Stokes had mentioned his name, and the manner in which they had received it. The toast was an important one, and he had prepared a speech, which he did not feel justified in inflicting upon them at that late hour of the evening.

We give the text of the speech:—Without unjustifiable vanity I may be allowed to say that the Electrical Engineers have abundantly justified their existence. But instead of smooth prophecies or perching on the highest "dead" wire and crowing, it may be better to take a bird's eye view of the solid work that lies ahead. I have already referred to certain unsolved problems of electric energy. In the list of momentous problems the action of electricity on animal and vegetable life is not the least important. As regards the treatment of disease, the subject is temporarily overclouded by falling into the hands of advertising quacks. In respect to vegetation, it is still uncertain whether electrical currents exercise any decided or uniform influence upon growing crops of grain and fruit; whether such influence would be favourable or the reverse. Recent experiments lead to the opinion that electricity may induce earlier and better harvests. But much further study is here needed. Nor have we yet solved the equally important and closely connected question, whether we may by electrical action rout the parasitical insects and fungi which in some seasons rob us of no less than the tenth of our crops. A moderate estimate puts the mean loss in the home kingdoms at £12,000,000 per annum. In India and the Colonies a number of destroyers, which it is not my business to specify, are less easily contented. Like Falstaff, in the words of Dame Quickly, they seek to take "not some, but all." The attacks of the phylloxera have cost our French neighbours more than did the Franco-Prussian war. It has been found in not a few experiments that electric currents not only give increased vigour to the life of the higher plants, but tend to paralyse the baneful activity of parasites, animal and vegetable. Here there is unlimited scope for practical research, in which the electrical engineer must join forces with the farmer, the gardener, and the vegetable physiologist. We have definitely to decide whether, and under what circumstances, electricity is beneficial to our crops, and whether, and under what conditions, it is deadly to parasitic pests. Here, then, comes the question of a supply of electricity cheaper and more universally applicable than the tedious conversion of chemical energy into heat, of heat, again, into mechanical power, and of such power into electric current. It is depressing to reflect that this roundabout process, with losses at every step, is still our best means of obtaining a supply of electricity. With regard to the possible applications of electricity to agriculture, I may mention that the total amount of *vis viva* which the sun pours out yearly upon every acre of the earth's surface, chiefly in the form of heat, is 800,000

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H.P. Of this mighty supply of energy a flourishing crop utilises only 3,200 H.P., so that the energy wasted per acre of land is 796,800 H.P. We talk loudly of the importance of utilising the refuse of our manufactures; but what is the value of alkali waste, of furnace slags, of coal tar, or all of them together, compared to the loss of 796,800 H.P. per acre of land? The application of electricity to sanitary improvements is another possibility, turning mainly on a cheap supply of current. The electric treatment and purification of sewage and industrial waste water is a demonstrated reality which merely requires a reduction in the cost of the agent employed. The sterilisation by electrical means of the water supply of cities has been proposed and discussed. Theoretically it is possible, but the practical difficulty of dealing with the vast volumes of water required for the daily consumption of London is prodigious. But a difficulty, said Lord Lyndhurst, is a thing to be overcome. There is a still more important consideration; the living organisms of water are by no means all pathogenic. Many are demonstrably harmless, and others possibly beneficial. Before the sterilisation of our water sources can be prudently undertaken, this great question must first be decided by experimental biologists. Another point at which the practical electrician should aim is nothing less than the control of the weather. The question is, cannot the accumulations of electric energy in the atmosphere be thwarted, dispersed, or turned to practical use? In like manner we may hope to abate the terrible fog nuisance. Nature supplies energy amply sufficient. How is this prodigious quantity of power to be made available? These are problems that may safely be left to the devices and inspirations of our electrical engineers. I have given you some indication of the intricate problems to be handled, of enormous difficulties to be surmounted. What is really in store in the way of future wonders is folded "in shady leaves of Destiny."

CORRESPONDENCE.

THE USE OF ELECTRIC MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read with mixed interest and disappointment your article of October 30th on the use of electric motors. Whilst you are entitled to the thanks of electrical engineers for drawing attention to this important matter, yet I must confess that I think you have been unfortunate in your treatment of the subject. Many of your readers who have not closely followed the subject will put down your article with the sense that, after all, the use of electric motors will be extremely limited. I cannot hope that my letter will be as widely read as your article, still I wish by putting the following on record to show that the case is not as you put it. The mistake you have made throughout is a very common one, viz., you estimate the cost of working the system at the cost of only one of its items. In comparing the cost of gas motors with electric motors you have set the cost of gas against that of electricity, as if this alone would determine the choice of the intending user.

If you study the interesting question of the introduction of labour-saving machinery, whether for the generation of energy or for its utilisation, you will find that the first question put by an intending user of a labour-saving appliance is not what will be the cost of power and attendance required to run it, but what will be its first cost, and in what time may he expect to repay this first cost by the economy it introduces. If a maker of a combined wood-sawing and moulding machine to be worked by gas or electric power wished to push its sale amongst the smaller class of London furniture-makers, who have hitherto entirely trusted to hand labour, the first advantage he would claim for the electrically-driven plant would be that it would only cost £40, whereas the plant driven by a gas engine could not be put down under £160. He would then call attention to the case of starting and stopping, and hence the comparative handiness of the electrically-driven plant, and would certainly point out that the time during which the power would be required would be so short that the difference of cost of gas and electricity would not tell prejudicially against the electric motor.

The whole subject of the "load factors" of machine tools is a very interesting one to mechanical as well as electrical engineers. Of course I use "load factor" in the sense that I used it in my Paper read before the Institute of Civil Engineers on the cost of electrical energy; but to those who have not read that Paper I must explain that I mean by "load factor" the proportion that the total number of hours at which any plant is worked at full load bears to the total number of hours in the year. Very few people have taken the trouble to calculate how many hours the various classes of labour-saving machinery are kept at work and absorbing power; but I believe it will be generally admitted that the class of tools which it is intended to drive by electrical motors are used very intermittently, so that the actual hours during which they take power rarely exceeds 300 per annum. It follows that the cost of the power itself during this small number of hours bears quite a small proportion to the percentage costs, such as interest on capital outlay, repairs, &c. This fact tells very strongly in favour of motors, which cost little in the first instance, even if they are costly in their use of energy; but I go a step farther, and challenge the accuracy of your statements of the comparative cost of gas and electricity during the times that both classes of motors are actually at work. The figure you give of 1d. per hour for a small gas engine is misleading. In all probability it would be found that most gas engines are not worked intermittently, but are run for long hours very lightly loaded. This fact alone increases the average cost of the power (*i.e.*, divided over the time that they are actually doing useful work) from 1d. up to 3d. or 4d. If the cost of oil, cleaning, material, and the extra cost of attendance is added to this, in all probability the annual bill for electricity and attendance on the intermittently-worked electric motor will be found less than the annual bill for gas, oil, and attendance on the gas engine. Of course much depends on the number of hours during which the motor is used. For continuous work, such as ventilation, pumping water, driving electric lighting plant, or the like, the gas engine is undoubtedly the cheapest; but for most of the intermittent work for which machine tools are used, such as cutting wood, metal, or stone, or polishing gems, weaving, sewing, embroidery, and the like, the electric motor will be found to surpass its rival in every point. I think some of us who have had considerable experience in these matters are beginning to realise the fact that the field of the electric motor will extend into the mechanical workshop, and that the long lines of shafting at present used will be superseded by a system of driving each machine tool by its own separate motor. Such a change will result in great convenience of arrangement to our workshops, and in great reduction of the cost of the energy used.—I am, &c.,

R. E. CROMPTON.

Mansion House Buildings, London, E.C., Nov., 18, 1891.

THE THEORY OF THE WIMSHURST MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to your Note of the 6th inst., allow me to say that I was led to enunciate this attempt at a theory of the Wimshurst machine while translating Gray's book on "Electrical Influence Machines." The theory given by the author, I now see, is no other than that of Prof. Thompson. I discussed the matter in *La Lumière Electrique* of October 10th.

Besides the difficulty one finds in explaining how it is produced, the *primitive* distribution of electricity on the plates—(+) on one half (−) on the other—does not seem to me worthy of acceptance, for the following reasons.

This theory does not take in account at all how the machine works when it is primed by the influence of a foreign body placed in front of a brush, β for example. You know that in this case, according to the sign of the influencing body, the direction of the current may be reversed. It is impossible in this instance to assume the pre-existing charge, and we are led to conclude that the action of the machine consists precisely in establishing the known electrical distribution.

It was the mechanism of this distribution that I sought to explain, for it is in it that the whole action of the machine seems to me to reside, since the growth of the charges is merely the consequence of the electrifications established. To assume that this distribution exists on the plates independently of the action of the apparatus seems to me to be a very imperfect way of explaining the phenomena.

I regret having to insist so much on this point, and having to trouble you with claims which have only a personal bear-

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ing; but I think it would be of interest to definitely settle the theory of the Wimshurst machine, and I shall be very happy if this discussion contributes to that end.—I am, &c.,

Paris, November 18, 1891. G. PELLISSIER.

THE MAGNETIC (*SIC*) LADY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As many of your readers may not have seen my letter in the *Times*, they may be interested to know that at any rate the above performance is a perfectly genuine one, no assistance whatever being given to the lady, and her force is distinctly self-contained.

I am by no means a stranger to the Alhambra stage, and I think that if it had been any question of stage trickery the Directors would hardly have asked me, at any rate, to have gone on the Committee.

From the earlier tests I was at first inclined to believe that it was only some process of hypnotic suggestion; and as I do not approve of mesmerizing performances, I took no active part in withstanding the lady's prowess. The subsequent tests, however, were of a totally different order, as the force exerted in many instances must have been enormous, and, as I had hold of the lady's fleshy, but not muscular, arm on several occasions, I can safely say that muscular power was not brought into play, the biceps remaining quite supple.

To me the most interesting experiments were those in which the force was not exerted direct on the object, and on as many occasions as I could I placed my palm between Miss Abbott's hand and the chair or cue. The lady did not touch the object except through my hand, and although I kept this motionless I endeavoured to exert an active influence the reverse direction of what was desired. On the occasion when she moved off the ground the two chairs with six heavy men on them, and when from the great trembling of her arms some great force must have been brought into play (although her muscles were inert), I felt a vibratory agitation through my hand somewhat similar to what I have on certain occasions experienced when near a powerful dynamo.

Surprise has been expressed that the billiard cue did not break when three or four men were pushing against it; but I would point out that objection was taken to anyone placing their two hands side by side, as the lady did not appear able to exert any power against the particular "circuit" thus formed by one body. By thus distributing the hands the strain was not so much at the ends of the cue, and the force and weight were more spread over the centre of it; however, on the occasion of the four men attempting to force back the cue it bent to almost breaking point.

Unless one has been so intimately associated with the performance as I was, it is quite impossible to understand the profound impression it produces, and certainly the whole exhibition is of far greater scientific and general interest than any of the objectionable mesmerism entertainments that have recently become so frequent.

I believe it is intended on every occasion to have gentlemen from the audience on the stage, and I am sure the management would give a preference to any electrical engineer at all well known who desires to have an opportunity of thus closely watching the performance.—I am, &c., JOHN B. VERITY.

November 17, 1891.

RAILWAY RATES AND CHARGES.*

The appended particulars are prepared to show the chief results attained by the London Chamber of Commerce and other bodies in their opposition to the original proposals made by the various railway companies under the Railway and Canal Traffic Act, 1888. The schedule to the London and North-Western Provisional Order Act is selected as being that upon which Parliament chiefly grounded its action. Those who have had any connection with the various proceedings resulting from the General Act are aware of the immense amount of detail involved in the discussion, while outsiders may gain some idea of the cost entailed in a Parliamentary procedure of this kind when it is stated that the expenditure of the London Chamber alone has been nearly £2,000. On the whole the results attained, when compared with the pretensions of the railway companies as indicated in their original proposals, must be considered as satisfactory, although, perhaps, the limit originally laid down by the Board of Trade, namely, that of the present actual charges of the companies, has not been quite attained in the statute. Taken generally, it will be found that the Provisional Order Acts practically limit the maximum charging powers of the companies in respect of the various classes in which the goods and merchandise are arranged to those exercised under the Railway Clearing House regulations. If the powers conferred on the companies had been limited to the actual rates the trading community would not have been in a position to make any adverse criticism; but to these rates must be added the charges which the companies are allowed to make under the head of station and service terminals. These will involve a considerable increase on the rates charged under the various classes; but even with their addition, it must be recognised, in fairness to the Board of Trade, that the present powers of the companies are, in comparison to the powers which they held previously, very materially reduced. As far, therefore, as these reductions go, the trading community can claim that they have obtained a practical result in their opposition to the Railway Companies Bills.

The following items are worthy of perusal in detail, the respective gains they show, as compared with what would have been obtained by the companies had their first propositions been sanctioned, being apparent at a glance.

ARTICLE.	Railway Clearing House.	Original Proposals L. & N. W. R.	Provisional Order Act.
Sulphuric acid	exceptional class	exceptional class.	exceptional class.
Batteries, telegraph, packed	3	5	3
„ electric, storage.			
„ ("electric batteries")	2	3	3
„ ("electric accumulators").	2	—	**2**
Cable (telegraph)	4	5	3
„ (electric)	4	4	3
Carboys, not glass, empty not returned	4	5	3
Carboys, ditto glass	3 (1 ton)	5	5
Castings, iron malleable	1	2	1
„ light, packed	1	2	1
Delta metal	2	3	**2**
Disencrusting fluid, in casks	2	5	3
Dynamos and electric machinery, packed	2	not specifically classed.	not specifically classed.
Ditto, not packed	3	ditto.	ditto.
Insulators, telegraph, packed	1	5	1
„ electric, glass	2	2	**2**
Iron, sheet or plate (annealed)	1	5	**C. & 1.**
Mouldings (common wood)	3	5	3
Posts, telegraph, iron or steel	1	1	**C. & 1**
Reflectors, glass, with metal backs.	4	5	**4**
Sponge cloths	2	5	3
Steel, bars and bundles	2	2	**2**
Wire, cotton-covered, packed	2	4	2
Telephone apparatus, packed	4	5	**4**

Where a gain compared with the proposals of the Railway Company has been registered in the Provisional Act, this is shown by the use of a blacker type.

TRADE NOTES AND NOTICES.

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

SALES BY AUCTION.—Our advertisement columns contain particulars of the sale by auction by Messrs. Wheatley Kirk, Price, and Goulty, on Wednesday, December 2nd, of the engines, boilers, shafting, machinery, &c., belonging to the International Cotton Waste Company, Limited (in liquidation), 449, Old Ford-road, London, E.

——— The valuable stock of new and exhibition engines of the Beck Gas Engine Company, Limited (in liquidation), together with the British and Colonial patents, &c., are to be sold by auction at the County Hotel, Newcastle-on-Tyne, on Wednesday,

* From the *Journal of the London Chamber of Commerce*, Nov 10, 1891.

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December 9th. Further particulars appear in our advertisement columns.

TENDERS ACCEPTED.—The Corporation of St. Helens have, in connection with the proposed electric lighting of the Town Hall, accepted the tenders of Messrs. Bumsted and Chandler, of Cannock Chase Foundry and Engine Works, Hednesford, Staffs., for supplying the engines, dynamos, and boilers, at £864; and of Messrs. J. D. F. Andrews and Co., 41 and 42, Parliament-street, London, &c., for the necessary wiring, at £419.

REMOVAL NOTICES.—Messrs. Appleton, Burbey and Williamson have removed to 92, Queen Victoria-street, London, E.C.

——— Messrs. Barnett, Wynne, and Barnard have taken possession of their new premises, Volt Works, Walker, Northumberland.

NEW FIRM.—Mr. Robt. W. Paul, who was formerly with Messrs. Elliott Bros., informs us that he has taken workshops and office at 44, Hatton-garden, E.C., and has commenced business as electrician and scientific instrument maker. Mr. Paul took the Honours Medal of the City Guilds for instrument making in 1887.

DISSOLUTION OF PARTNERSHIP.—Messrs. Arthur B. Gill and Co., electrical engineers, of 36, Parliament-street, Westminster, and Bermondsey, have dissolved partnership. The business will, we understand, be carried on by Mr. Arthur B. Gill alone.

MESSRS. EDLIN AND STEVENSON.—We learn that Messrs. Edlin and Stevenson have now settled down in their new premises at Cape Town. Their offices are situated in Alderley-street, and their stores at Church-street. Telegraphic address, "Electrical, Cape Town."

ELECTRIC LIGHTING AT LIVERPOOL.—With reference to our Note of last week *re* electric lighting of Messrs. Henschberg and Ellis's new premises, we are informed that the work was carried out to the specification and under the superintendence of Mr. T. L. Miller, consulting electrical engineer, 7, Tower-buildings, Water-street, Liverpool. The large main switchboard used in the installation was supplied by Munro's Manufacturing Company.

DROITWICH.—The electric bells at the recently-opened Worcestershire Brine Baths Hotel at Droitwich were fitted up by Mr. E. H. Hill, of Birmingham.

MESSRS. J. G. STATTER AND CO., LIMITED (IN VOLUNTARY LIQUIDATION).—A meeting of the shareholders of this Company (which, as our readers will remember, became absorbed in the Electrical Engineering Corporation, Limited) will be held at 3, Prince's-mansions, Victoria-street, S.W., on December 19, at 1 p.m., to receive the liquidator's account of the winding up.

MESSRS. DRAKE AND GORHAM.—This firm have just installed the electric light at Felsted, which is the first public school in the country to be so lighted. The electricity is generated by a double set of engines and dynamos, and there is an accumulator battery of 53 cells. Three hundred and eighty-five Swan-Edison incandescent lamps are used to light the school buildings.

ALLCHIN, LINNELL AND CO. (LIMITED).—The public examination in this matter has been appointed for November 25th, at 11, at 34, Lincoln's Inn-fields.

THE FIRE AT MESSRS. LAING, WHARTON AND DOWN'S.—Messrs. Laing, Wharton and Down inform us that a disastrous fire occurred on Tuesday night at their works. They are, however, making arrangements which will enable them to execute orders as promptly as ever if customers will kindly give them their indulgence and a few days' grace.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

October 5, 1891.

16,870. T. SUTCLIFFE and E. H. ATKINSON. London. Improvements in the combination of electrical brush, brush-holder, and lubricator.

16,875. J. GRANT. Glasgow. Improvements in automatic electrical apparatus for signalling and preventing accidents on railways.

16,895. J. B. SPURGE. London. Improvements in electric arc lamps.

16,931. E. C. GRASSOT. London. Improvements in electric meters. [Date applied for under Patents Act, 1883, Sec. 103, 4th April, 1891. Being date of application in France.]

October 6, 1891.

16,934. H. H. LAKE. London. Improvements in secondary batteries. (P. Kennedy and C. J. Diss, United States).

16,938. H. H. LAKE. London. Improvements in secondary or storage batteries. (P. Kennedy and C. J. Diss, United States).

16,941. A. P. LUNDBERG. London. Improvements in switches for electric lighting.

16,958. H. A. MAYOR, W. A. COULSON, S. MAYOR and W. B. SAYERS. Glasgow. Improvements in or relating to metallic junction boxes or cases for conductors or fittings for electric lighting, electric bell circuits, and like purposes, and in the mode of connecting the conductors thereto.

16,989. H. H. LAKE. London. Improvements in printing telegraphs. (M. G. Farmer, United States).

16,991. F. H. W. HIGGINS. London. Improvements in type-printing telegraphic apparatus.

17,003. A. F. MADDEN. London. Machines for making grids for secondary batteries.

October 7, 1891.

17,032. T. SMITH and J. C. HALL. London. Duplex plates or discs fo electrical health appliances.

17,042. J. MACHAFFIE. Glasgow. Improvements in and relating to dynamo-electric machines applicable for the traction or propulsion of any vehicle, vessel, or body, as well as for all purposes to which dynamo-electric machines may be suitable.

17,074. J. C. REILLY. London. Improvements in electrical subways.

October 8, 1891.

17,107. J. H. RIDER. Halifax. Improvements in electric arc lamps.

17,118. T. TUBINI. London. Improvements in arc lamps.

17,119. W. C. CHEESEWRIGHT. London. Improvements in electrical switches.

17,148. W. B. SAYERS. London. Improvements in electrical switches.

17,160. H. H. LAKE. London. Improvements in and relating to electric accumulators. (La Société dite Electriciteits Mattschappij—Systeme de Khotinsky, Germany).

October 9, 1891.

17,192. A. WRIGHT. Brighton. Improvements in electric distribution.

17,220. S. Z. DE FERRANTI. London. Improved means and apparatus for commutating or rectifying an alternating current.

17,227. J. C. HOWELL. London. Improvements in electric cables.

17,231. SIEMENS BROS. AND CO. (LIMITED), J. NEBEL and F. H. VALTER. London. Improved winding for drum armatures of dynamos and electromotors.

October 10, 1891.

17,264. J. RICH. London. An improved self-winding electric clock.

17,291. W. MITCHELL. London. Improvements in electric soldering irons.

17,310. L. VON ORTH and E. BRESLAUER. London. Electric signalling apparatus for use with a network of electrical lines or conductors

SPECIFICATIONS PUBLISHED.

1890.

17,711. EDMUNDS. Distribution of electricity. (Price 11d.)

18,158. GRAY. Electric pressure indicator. (Price 8d.)

18,270. MUNRO. Electrical conduits. (Price 8d.)

19,239. BARTON. Electric switches. (Price 8d.)

19,486. BENNETT. Telephonic switching apparatus. (Price 8d.)

19,650. SIEMENS BROS. AND CO. (Siemens and Halske). Distributing electricity. (Price 8d.)

1891.

9,683. RAWLINS. Electric primary batteries. (Price 6d.)

12,046. SAHULKA. Electric motors. (Price 8d.)

15,597. TISHER (THOMPSON). Galvanic battery. Price 6d.

15,621. CURRIE. Secondary or storage battery. (Price 8d.)

15,645. GREENFIELD and KINTNER. Ceiling blocks and cut-outs for electric light circuits. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

West India and Panama Telegraph Company (Limited).

The twenty-ninth ordinary general meeting of the members of the West India and Panama Telegraph Company (Limited) was held at Winchester House, Old Broad-street, on Tuesday, "to receive the report of the Directors and the accounts for the six months ended June 30, 1891, to declare dividends, and to transact other business of the Company." Mr. C. W. Earle presided.

The SECRETARY (Mr. R. T. Brown) read the notice convening the meeting and the minutes of the last meeting; and the report of the Directors was taken as read.

The CHAIRMAN: The report deals with a period which I am afraid was not very prosperous to West Indian commerce. At any rate it was not nearly so good as in the corresponding period of 1890 it would appear to have been, judging from our traffics; and I do not think we can have a better barometer of the commercial doings of countries like the West Indies, where there is no great Stock Exchange speculation like there is in New York, and, fortunately, no revolutions as there have been in South America. I think that in such a country as that the traffic receipts form

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a very good barometer and test of what business is doing. Before the appearance of the French cable in our territories took place, which was in the beginning of June, the decrease in comparison with the previous year amounted to 10 per cent., and I should presume that this decrease was owing to the bad sugar crop. Perhaps, Sir George Chambers will correct me if I am wrong on that point. The whole decrease in our receipts amounts for the half-year to £4,710. As a set-off against this loss, we have a saving of £1,800 in the expenses; and the balance of £22,773 is what we have to deal with, as compared with £25,681 in the corresponding period of the year before, making a net deficit altogether of £2,910. Well, gentlemen, as you see by the report we have placed £2,000 to the reserve fund, and we propose, with your sanction, to pay the dividends upon the Preference shares, and to pay one shilling per share, free of income tax, to the ordinary shareholders. Now, the set-off of £1,800 is attributable to the reduction in the cable repairs under Abstract C, of the accounts. We had the good fortune to have only seven interruptions to our cables as against 12 in the corresponding period of the previous year, and we spent in repairing these interruptions 44 knots against 72 in the former period. If it had not been for the larger cost of cable this year, the reduction in expenditure would have been very much more, but as you all probably know, iron and copper and certainly gutta-percha and wages, had a great rise a year ago; and the result of it was that our stock of cable, when it got out to the West Indies, cost some 40 per cent. more than it had done of late years. I do not intend to take up your time with any close analysis of the debit side of the revenue account. There is, in fact, very little to remark upon. Some items are larger than they were in the corresponding period of 1890 and some are rather less, but on the whole, there is a balance of £200 against us, and that is caused by the allowance of some small sums to various clerks—a matter which is likely to be set right the next time we present an account. I now turn to what you will doubtless think the most important part of our report, viz., that which treats of the competition that has appeared in our system. You have been informed from time to time both in our reports and in my remarks to you at our meetings, of the approach of this competitive cable. I think that the first time we had to apprise you of the possibility of the danger was in 1887, when the then Minister of Posts and Telegraphs in France brought in a Bill in the Chamber of Deputies to grant a guarantee of £40,000 a year to a line of cables between North and South America, touching the French Colonies of Guadeloupe, Martinique, and Cayenne on its way. Well, the Chamber of Deputies threw out the Bill—I suppose because they did not see what interest France as a nation had in a line connecting two foreign countries on the other side of the Atlantic. The project appeared then to drop, but in 1888 a French Company, which is not so formidable a competitor as it would have been with a guarantee of £40,000 a year, laid a cable from Cuba to Haiti, St. Domingo, Curaçoa, and Venezuela; and we announced in our report of April last year that the same Company had obtained the transfer to itself of the subsidy hitherto paid us by the Government of Martinique. We then were made aware that it was preparing to compete with us at Guadeloupe and Martinique, where we have been established for 20 years. As announced in the present report, this line was opened for traffic early in June last. We had no intimation of the tariff at which they intended to work; and as their rates on the Venezuela cables, which had been in operation for some time, were higher than the rates on our lines mile for mile, we did not suppose that they would adopt the ruinous policy of working at rates below those which we had found by long experience so inadequate. However, I suppose for some object of their own—probably to get the French subsidy—they opened at a tariff of 2s. a word below ours for Guadeloupe and Martinique; and we, deeming it expedient to prevent diversion of the traffic, and to put our own Colonies on as favourable terms as the French Colonies, made proportionate reductions at our more distant stations. The result has been what anybody acquainted with the effect of tariffs in countries like the West Indies would foresee, a considerable decrease in our revenue. But you must not attribute all the decrease our traffics are showing to the effect of competition. We have made a calculation of how much of the loss we are incurring is owing to the competition and how much to the natural loss of traffic; and it would appear that more than one-half of the loss we have sustained by the two is attributable to declining traffic, that we are sending fewer words at the lower tariff than at the higher. I therefore hope and trust it is a very exceptional position. It is difficult to imagine a less justifiable competition from the point of view of what is to be earned. We have proved by the experience of many years that there is not traffic enough in the West Indies to support one Company properly; and the appearance of another in the field, where the telegraphic service has always been carried on at less than cost price—for we have never been able to earn anything approaching to a fair return on the capital embarked—can only be disastrous to the new comers, costly to us, and in the long run disadvantageous to the public. Well, gentlemen, I suspect that our competitors are already beginning to find that West Indian Telegraphy is not a business in which to make fortunes. They now have two cables broken down; and, as far as I know, no means on the spot of repairing them, and I am inclined to guess that the short experience they have gained is somewhat discouraging. However that may be, we are in for a competition struggle. It is not one of our seeking, but has been forced upon us, and we must go through with it; because there is no other course open to us. We have tried and failed. We are better prepared for it than our adversaries; our lines are duplicated—they are dependant upon single cables; we have our ships and our establishments for the storing of cable for repairs—the French Company at present have none. By your wise provision and self-denial a fair reserve has been established to meet possible contingencies; and, although we must suffer in our revenue while the contest lasts, we hope that our losses, disappointing as they are just as we appeared to be entering into a more prosperous condition, will not continue to be so severe as the present traffic returns indicate. We have to-day had the traffic return for the last fortnight, which is much more favourable. It shows a loss, but, compared with the losses we have had recently to announce, it is very satisfactory. I am informed that the next year's crop of sugar promises well, and if that harvest is a good one we may return to at least the same volume of traffic as we carried last year. I have now only to ask you to continue to give us the confidence we have now enjoyed for 17 years, and to remember in our discussions to-day that it is not wise to hold a council of war with open doors, as these meetings unavoidably have to be held. I now propose:—

"*That the Directors' report and accounts to June 30th, 1891, submitted to this meeting, be and the same are hereby received and adopted; and that, as recommended by the Board, a payment of 6s. per share on the First Preference, 6s. per share on the Second Preference, and 1s. per share on the ordinary shares be and the same is hereby declared.*"

Mr. WILLIAM FORD: I beg to second the resolution, and, at the same time, I gladly avail myself of the opportunity of thanking you for the very cordial manner in which my re-election was voted at the last half-yearly meeting, when I was prostrated with a severe attack of influenza. Gentlemen, I can assure you that if prudence permitted, it would be a great satisfaction and relief to me to be enabled to place before you, as I have done on former occasions, my personal views as to the position and prospects of this Company; but concurring as I do in the views expressed by my honourable friend the Chairman, I feel that it would be exceedingly imprudent in me to say anything more than this, in the abstract—that I believe this Company was never in a better position to meet the adverse interests opposed to it, and I believe that we must in the long run succeed. I am not fond of using the language of Jingoism; but if I were I should say certainly that we have got the men in the able managers of submarine cables who sit at our Board, that we have got our repairing ships, and that in our reserve we have got the money too. The national sentiment, as I will call it, in which this French cable had its origin is all very well in its way, but national sentiment will not earn dividends on capital; and I am perfectly satisfied that this cable was as commercially unnecessary as I believe it will prove unprofitable to its owners. With these observations I beg to second the motion.

Sir GEORGE H. CHAMBERS said that it had not been his intention to offer any remarks, because he was quite alive to the circumstances referred to by the Chairman and by Mr. Ford. As, however, the Chairman had alluded to him by name, he had great pleasure in stating that what that gentleman had said was strictly accurate, and that the decline in their revenue might be attributed entirely to the bad weather in the West Indies, which caused the crops in many instances to be less than half what they had previously been. Therefore he entirely concurred with the Chairman that with the prospect now before them of perhaps more abundant crops than ever, they might see a return to the figures to which he had adverted. The accounts before them showed that the net revenue of the Company for the six months to June 30th was equal to paying a dividend of 3s. per share for the half-year upon their ordinary shares. He would have preferred, remembering the many years during which the ordinary shareholders were without a dividend, that instead of taking one-third of the net revenue for dividend and two-thirds for the reserve fund, the Board should have taken two-thirds for dividend and one-third for reserve, and he thought that this might safely have been done. Nevertheless, as they had competition to face, it was, perhaps, better that they should keep on the safe side. Probably there were some gentlemen present who knew that he was a warm advocate of a reserve fund, which had been found extremely valuable in the case of another Company with which he was connected, enabling that Company, as it did, to hold its ground while ruin befell its opponent. He therefore never objected to a moderate reserve fund. Sometimes competition was not altogether a loss. He knew some occasions where competition had increased the traffic, and he thought that that might very likely occur in their own case. He hoped that with the prospects they had in regard to the coming crops they would be able to receive from the Chairman an even more satisfactory account at their next meeting than, as he considered, had been made to them that day.

Mr. CHAMBERLAIN enquired how much the Company had lost by the reduction of the takings since the beginning of the present half-year?

The CHAIRMAN: The aggregate decrease for the four months of June, July, August, and September was £5,576; but, as I said before, more than half of that is attributable to the smallness of the number of the words telegraphed—the falling off in our trade.

Mr. THORP remarked that a previous speaker had alluded to the carrying over of such a large amount, and he himself thought that this was a very fair subject for comment. He did not object to putting £2,000 to the reserve fund; but why should they carry forward £5,200, when out of this amount they could easily pay another shilling a share dividend and carry forward £300?

The CHAIRMAN: Because we have very heavy repairs going on this half-year, and the traffic is, as I have said, very bad compared with what it was before. Unless we save something this half-year by carrying over a large sum, we may not be able to pay our Preference Dividends next half-year; and, as these dividends are cumulative, they would hang over the ordinary shares and make things as bad as they were before.

Mr. THORP, continuing, said that his point was that the money which had been earned in the past half-year belonged to the ordinary shareholders. It ought not to be paid in dividend to the First or Second Preference shareholders, who, no doubt, had the right to cumulative dividends. They had not the right, however, to retrospective dividends; and if the money now in hand was not paid to the ordinary shareholders, it would be absorbed by the Preference shareholders, who would thus be placed in a better position than that which they were entitled to hold. They had a very long "pull" of it if they had to wait for a half year, whereas the ordinary shareholders had to wait many years. He,

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therefore, thought it was only fair that the earnings which had now been made should be paid to the ordinary shareholders, as they had the right to them.

Mr. WILLIS observed that for the half-year ended December, 1890, the Directors paid a dividend of 9d. per share, and carried forward £668, but nothing was added to the reserve fund. Now, however, it was proposed, after putting £2,000 to the reserve fund, to carry forward £5,255, while in his opinion the Directors might pay, on the same principle as in the previous half-year, 2s. 6d., and carry forward the same amount, or just about the same within £30. The ordinary shareholders had had, he believed, one dividend in 14 years at 9d., and he really thought that it was a very great hardship that they should be kept out of their dividend when the First and Second Preference shareholders had had their dividends in full. They might have had to wait, but they had been paid in full; and taking into consideration what the Chairman had said with respect to the abundant crops they were likely to have, he thought that at least 2s. a share dividend should be paid to them. The Directors would then be able to carry forward a very large sum, seeing that on the previous occasion only £668 was carried forward and a dividend of 9d. paid. He felt very strongly inclined to move a resolution to the effect that the dividend on the ordinary shares should be 2s., and that the balance then remaining should be carried forward.

Mr. W. GRIFFITH said that, as an ordinary shareholder, he rather sympathised with the remarks which had been made as to the dividend not being larger this year; but still, he thought that the policy of the Board was in this respect a sound one. If a larger dividend were paid and the receipts were to fall off, and if their cables were to break, they would have to appropriate a much larger proportion of the revenue to the repair of the cables. Although, therefore, they put the money by it was for the advantage of the Company at large—for the ordinary as well as for the Preference shareholder. The interest paid to the latter was limited, but it was a cumulative charge, and if once their reserve fund got into disorder and their cables were broken, as was the case a few years ago, the payment of a dividend on the ordinary shares would again be indefinitely postponed. He did not think that they were likely to be indefinitely postponed if they had a fair reserve fund. He was not in favour of increasing the reserve fund beyond what was necessary to ensure the safety of their cables, but the present was a somewhat critical time for them. Sir George Chambers has said that he hoped competition would increase their income, but unfortunately it had not done so hitherto; and he did not think that competition would be a benefit to them in time to come. Our West Indian Colonies differed very much from the Northern States, where great energy was shown. The trade of the West Indies was very stationary, and the Governments were very conservative as to free trade. They imposed very heavy taxes on all goods that were imported, and trade was to a great extent hampered by our own Government. If the West Indian Colonies could be persuaded to adopt a more liberal tariff towards English merchants they would benefit greatly. It must be remembered that the Company's system was a very complicated one. They supplied the telegraph wants of Danes, Spaniards, French, and others. Unfortunately, they had lost the French traffic to some extent, but; fortunately, on the other hand, the French traffic was only a small part of the traffic from the West Indies. From this circumstance he thought that they might draw some hope that when the good times of the harvest came their traffics would be increased, and that the ordinary shareholders would reap the proper reward for the very great patience which they had displayed.

The CHAIRMAN: We have not got a complete return of the traffic from the beginning of this half-year. There was an interruption to one of our lines, and we had to transmit the traffic by another way; and until we get the papers we shall not know what the returns exactly were. The returns we received were stated to be unreliable, and I will not pledge myself to any figure. You may, however, form a very good idea when I tell you that for June, July, August, and September, the aggregate decrease was £5,576.

Mr. CHAMBERLAIN said that before the Chairman replied he desired to make a few remarks. Several shareholders had spoken against the policy of the Board in adding to the reserve fund the sum proposed, and in carrying forward such a large amount; but he wished to say, as an ordinary shareholder—holding two or three times as much in ordinary shares as in First Preference shares—that he entirely approved this policy, and he thought it was to the interest of the ordinary shareholders quite as much as in that of the Preference shareholders, or more so. The reason he had asked for the information about the returns was that he had wanted to see how far they made the position of the First Preference shares secure without the reserve fund. He hoped that the position of the First Preference shares was secure, and that their returns would not fall off to such a serious extent as to prevent the payment of the Preference dividends. In any case, however, he would remind the ordinary shareholders that it was to their interest, as far as possible, to obtain a regular dividend, however small it might be, rather than a large amount one year or one half-year, and nothing at all for two or three half-years in succession. What was set aside by the Directors at the present time was in hand at all events, and though they did not divide it that day it would be divided hereafter. They would, therefore, not lose anything in the shape of dividend, and if they had to part with their shares they would gain by their improved market value. In addition to this the Chairman had said that it was not desirable to discuss too closely their position in view of the competition of the other Company. They were in active and very severe competition, and he thought it was most important that the Directors should be able to show the foreign Company that they were in a very strong position. The Board would be much better able to deal with this competition if they showed their rivals that they had the support of their shareholders, and that they had large funds at their disposal to make the position of the Company secure.

Sir GEORGE CHAMBERS said that the West India Colonies had had to bear the brunt of emancipation, the admission of slave-grown sugar, and to face the bounty-fed sugar from the Continent; and he thought that Colonies which had had to go through such difficulties deserved the sympathy and not the reproach of their fellow countrymen.

Mr. SAUNDERS said he thought that what the Directors proposed was not only judicious, but was also in the interest of the ordinary shareholders. It would be very bad for them if, by not looking after the reserves, the ordinary shareholders had to revert to their former position, with arrears of dividends on the Preference shares to be cleared off.

The CHAIRMAN: I can assure you that the question of how we were to deal with the balance at our disposal this year caused us very great anxiety; and we studied that question and debated it from every point of view. You must remember that we who sit at the Board know more of what is going on than we can tell you, or than any one else knows; and having regard to the heavy sums which we must pay for repairs and to the falling off in our traffic—which I hope is not going to be so serious as it was in the early part of the half-year—we came to the conclusion that it would be better to keep ourselves quite strong and to carry over a comparatively large sum to next half-year. I hope that our ordinary shareholder will not be the sufferer by this, and I do not see how he can, because if we fall into arrears with our First and Second Preference dividends, I am sure that the effect, the accumulating bad effect, on the ordinary shares is more serious than the loss of a dividend of 1s. a share. For 15 years there was the effect of a heavy weight of debt hanging over their shares, depreciating them, and doing them far more harm than going without a dividend.

Mr. WILLIS: Will you please answer the question why you paid 9d. before and carried over £600, while now you only pay 1s. and carry forward over £5,000?

A SHAREHOLDER: The explanation already given is quite satisfactory.

The CHAIRMAN: We cut our coat according to our cloth. He then put the resolution to the meeting in the usual way, and having declared it carried unanimously, stated that that concluded the business.

Mr. GRIFFITH proposed a vote of thanks to the Chairman and Directors for the conduct of the Company's affairs in the past half-year. They might, he said, differ a little as to policy; they might think that more might have been paid to the ordinary shareholders; but he thought they must have some confidence in the Directors for what they had done in the past. He might be permitted to remark, in reply to Sir George Chambers, that his sympathies for the West India Colonies were as great as those of that gentleman's. He, however, thought that the principle of free trade would be for their benefit. They were suffering now from the suicidal policy of the French Government as to bounties, but he hoped that that would not endanger their trade in other respects.

Mr. GREGORY seconded the motion, which was carried unanimously.

The CHAIRMAN: Gentlemen, we are very much obliged to you for your vote of thanks, and on behalf of my colleagues and myself I beg to thank you.

The proceedings then terminated.

Woodhouse and Rawson United (Limited).

The annual general meeting of the shareholders of this Company was held on the 13th inst. at the Cannon-street Hotel, under the presidency of Sir Rawson W. Rawson, K.C.M.G., C.B.

The SECRETARY having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, I have much pleasure in presenting you with an account of our stewardship during the past year—the second year of our existence. Considering the extraordinary financial crisis that has occurred during that year and the general commercial depression which ensued, we trust you will find the results of the Company's operations for this period eminently satisfactory. Deducting from both sides of the account the £16,000 brought forward from the previous year, you will find that the total earnings of the Company amounted to £89,000. Out of that we have provided for all our current expenses, and for what we consider a sufficient amount in reduction of the value of our patents. We have paid the interest due on our debentures, and have written off £10,500 for extraordinary expenses, some of which might fairly have been distributed over a further length of years; and we are left with a balance o £35,000 with which to meet our dividends of 15 per cent. on the ordinary shares and of 8 per cent. on the preference shares. These dividends will amount to £30,500. Consequently, having made a clear net profit of £35,000, we have a surplus of £4,600 applicable to such purposes as the shareholders may decide in agreement with the Directors. If we add to that the £10,000 of extraordinary expenses, our earnings during the year were £15,000 above our current expenses and dividends, without trenching upon the £16,000 brought forward from the previous year. The Directors hold, and we trust that you will hold, that in such an extraordinary year as that through which we have passed this result will be regarded as completely satisfactory, for it should be remembered that the character of the year peculiarly affected this Company, one branch of whose business is to avail itself of new inventions, to utilise the patents which it possesses, and to interest the public in new inventions connected with electricity. This, however, has been a year in which the public have not been disposed to enter upon new undertakings, and therefore we have had very little encouragement in this direction. We have had a number of proposals at different times, but we have not thought it right to accept them or to move in regard to them; and yet in spite of this we have made a clear net profit of £35,000. Passing to the balance-sheet, we have reduced the mortgages on freehold property by £3,000. The sundry creditors stand at £8,000 less. We have swept away the whole of the guarantee fund, which stood in the last balance-

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sheet at £75,000. We have repaid the whole of that to Woodhouse and Rawson (Limited), according to the authority which you gave us at a previous meeting. You find inserted here for the first time the item of reserve fund, £25,000; and the pension fund of £1,065 is for the benefit of our *employés*. Turning to the credit side, the freehold premises show an increase of £12,000, which is caused by the new building and the improvement of the engine power at Cadby Hall, and also sundry improvements in the Kidsgrove property, which was taken over at the commencement of the year and necessitated certain outlay. The three items of plant, stock, and expenditure on contracts in hand are very heavy, and show a large increase; but the explanation of that is very simple. We only commenced our work last year. The United Company having acquired new works, having made a new organisation, and having extended the business, I may say, throughout the world—in Australia, South Africa, and other parts—necessarily had to make a large outlay on works, plant, supply stations, stock, installations, and contract work for the business in progress. In fact, what did we ask money for but to extend our business? The explanation of the increase in these items is simply that we have extended our operations—legitimate operations connected with our trading and manufacturing pursuits—and it is an evidence of the increase of our business. At the commencement of our operations it was advisable to advertise largely; and another important matter is that we have prepared, and are on the point of publishing, certainly the best catalogue—the most complete and the most exhaustive catalogue—of electrical and engineering apparatus and subjects of supply connected with electricity of any firm in the world. We are very proud of it, and it is calculated very much to improve the standing and credit of the Company, and to extend our business throughout the world. The consequence has been that in the past year—and perhaps in the present year also—there has been a large amount, but not an improper amount, expended upon advertising and printing. We have thought it right to spread the whole of the cost of this over the past year and the present year, instead of over four or five years. We think it better to meet, as far as possible, all our expenses as they arise; and as our earnings are sufficient to cover them, we have charged in this instance half of this expenditure to last year's revenue, and we intend to charge the other half to that of the present year. The next item is patents, patent rights, &c., on which there is an apparent increase of £10,000. This has not arisen from any material addition to the patents which we possess, but from the completion of the purchase of two of the Woodhouse and Rawson subsidiary companies. We have not added to the value of our patent and goodwill, except in connection with the completion of this original contract. The same remark applies to goodwill as to patents.

Mr. SAMUEL POPE, Q.C.: It is the same as before, *plus* the amount of the two new Companies taken in since last year.

The CHAIRMAN: We find in the first balance-sheet only £11,000 under the head of sundry investments, but you must take into account that below that there was invested a sum of £75,000 which was reserved to repay Woodhouse and Rawson (Limited). Our investments, therefore, in the first year's balance-sheet were £87,000, whereas that figure now is £119,000. You would probably like to know what these investments consist of; but it would be opposed to your interests and the practice of companies if I were to give you that information here. All I can say is that the valuation of these investments has been taken at the lowest and most reasonable figure; and, as far as we know, they are investments, not speculative, of the nature of which you have perfect cognisance. Last year investments which stood in our balance-sheet were parted with at a price above that which they figured for in our books; and we hope that by not throwing these investments on the market in an unreasonable manner we shall be equally successful. Any gentleman present, if he is acquainted with business, knows that it would be attended with most injurious consequences, not only to ourselves but to the companies concerned, if we were to come upon the market in an ill-advised manner. We shall, however, dispose, we hope next year, of these investments upon equally advantageous terms as we have done others. Our Managing Director authorises me to say that we have already disposed of some of these investments, and every one of them beyond the price shown in the balance-sheet. The debtors have increased, but, of course, they will increase; £30,000 of the amount is guaranteed. I will now go to the profit and loss account. In regard to the first item of salaries, my relation, our very able Managing Director, is a sufferer. The salaries in the first year were largely increased by his remuneration, which, as you know, or you ought to know at all events, depends upon the surplus of profits in the year. The consequence is that as the surplus this year is very small—that is to say, the surplus after paying all claims, including the dividends—his remuneration is very small; and that explains the decrease under the head of salaries. There is a large increase under the head of debenture interest. With respect to the writings-off from patent and patent rights, we have applied £4,156 to this purpose, acting upon this principle. We consider that if we write off one-fourteenth, the "life" of a patent being 14 years, this item will be gradually written off and will disappear. I am eminded that some foreign patents are not limited to 14 years, but English patents are. Last year we applied £7,400 to that purpose, but this year we have not applied so much, though the two amounts make up two-fourteenths in the two years. We have therefore written off £11,500 from our patents, and we shall go on writing off one-fourteenth every year. If it be objected that the patents which we possess do not all have a remaining duration of 14 years, the answer is this—that for some of our patents we have paid nothing, and they do not stand in our books as possessing any value, although some of them are very valuable. With reference to another class of our patents, the only charge that we create in connection with them is the charge for registering them. Placing this circumstance against the fact that all our patents have not a "life" of 14 years, we consider—and I hope you will consider—that to deduct every year one-fourteenth off our patents is a reasonable calculation, and will bring us at the end of the 14 years to a clear sheet. The next item is income tax for 1890 and 1891. The income-tax for 1891 is a legitimate charge against this year's account, but the other is in arrear. It ought to have been introduced into the charges of last year, but we did not know the amount, and there was a dispute between the officers of the Company and the Inland Revenue with reference to the amount for which the Company was liable, That was not settled until this year, and therefore the income-tax for two years is charged in the present account. The mortgage debentures redemption account is explained by the sum paid to the holders of debentures bearing 6 per cent. for the redemption of these 6 per cent. debentures, and the acceptance of debentures at 5½ per cent. The next item is preliminary expenses, and the explanation of that is that the expenses actually paid in connection with the formation of the Company—various charges which it is impossible to explain in detail—were not paid in the first year. This year it has been considered proper to write off the whole charge. As to the item of £2,000 for the Cadby Hall removal, part of that is the estimated cost of the removal of our business from the one block in which it formerly existed into the new block. It is partly cost of removal and partly the loss occasioned by the shifting of machinery and works and the impossibility of undertaking new work while on the point of removing. All these we consider are proper charges against the year, instead of distributing them, as we might have done, over a wider range. On the other side of the account the gross profit was not so large as that of last year, but it is impossible to be blind to the fact of the very different state of circumstances which existed last year as compared with the preceding year and the opportunities possessed by the Directors of making profits. The balance of interest is £3,000 more. The item of rent is derived from our West Kensington lease, which did not appear in our other balance-sheet. The item of "premium on shares, transfer fees, &c.," remains the same The profit and loss account shows a profit carried to the balance-sheet of £51,439. We propose to transfer £10,000 to reserve fund, and to carry forward to next account about £9,000. I trust you will find that that is a very satisfactory explanation of our working during the year. The Managing Director—prompted, I believe, by an excellent colleague—points out that this brings up our reserves, made in our two years' working, to £45,000.

A SHAREHOLDER: £35,000.

The MANAGING DIRECTOR (Mr. Frederick L. Rawson): £45,000. We carry forward nearly £9,000.

The CHAIRMAN: I shall not detain you much longer, but there are two or three points in the report to which I should like to refer. Before doing that, however, there is an important point that I should like to speak upon, as I feel a personal and great interest in it—that is, the refusal to us of a quotation on the Stock Exchange. Lord Aberdare promised this as far as he could promise, and I did the same; and in all my communications with the shareholders I have stated my belief—I have given the assurance—that, as far as I knew, there was nothing to prevent our having a quotation. I have had full justification for holding this view. Our papers, after sundry references and considerable delays required by the Stock Exchange, were pronounced to be in order. We had every reason to suppose that we should obtain a quotation, and that the only cause of the delay was the convenience of the Committee of the Stock Exchange, some time being required by them to understand and examine our papers, which were voluminous. Three weeks before the quotation was refused we had the most reasonable expectation, from parties of the highest position on the Stock Exchange, that the quotation would be granted; and the refusal took us entirely by surprise. We had not the least knowledge why the quotation was refused, for the Committee of the Stock Exchange is autocratic, and does not give its reasons. The only surmise that we can form is this—that until the old Woodhouse and Rawson (Limited) Companies are wound up the Stock Exchange will not give us a quotation. They have, however, granted a settlement. We are given to understand that after reasonable delay we may get a quotation if we apply again. I hope you will allow us to use our discretion as to the proper time for doing so. My own impression is that we should not apply for it until the Companies I have just mentioned are wound up and we stand upon our own legs. There are two or three points in the report to which I will now refer. A very great improvement has been made at the West Kensington Works by the erection of the new block of buildings there and the new engine-house. This will enable us to undertake a class of business which is likely to prove highly profitable. The source of our credit and profit is the manufacture of specialities. We aim at giving the public special apparatus of value and importance. We have been confined hitherto to that class of business; but this new block of business will enable us to undertake on a large scale the manufacture of mechanical articles—for instance, type-writers, and articles of that kind requiring great delicacy and suitable to our *employés*. We have a whole floor, and a very extensive floor, in that building where we can turn out many thousands of machines. We have another contract which we hope to commence upon in a few weeks; and we look to have a considerable extension, both of business and profit, on this new branch. With reference to the Kidsgrove property, you must remember that we only entered into possession of it at the beginning of last year. That was a business that required considerable improvements in many ways, and we anticipated that when we bought it; but we had to carry out, at a disadvantage in many respects, the works begun by the previous owners of this property. All that has passed away, and in the coming year we expect very different results from the working of the Union Foundry at Kidsgrove. In acquiring this foundry it must not be supposed that the Directors have plunged into the acquisition of these works simply to make new business. The object of our acquiring the Union Foundry was this—we possess the means of making all electrical apparatus of a small character—switches and a variety of things of that kind, but we had no works where we could manufacture on a large scale dynamos and engines peculiar to electrical purposes, and to introduce new inventions—specialities, as I call

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them, such as are noticed in the report—hydraulic machinery, Mr. Bolton's electric cranes and winches, and things of that kind. That was our object in acquiring these works, and before we meet again I hope we shall be able to report a sound and profitable business in this respect. I may pass over the Cornbrook Telegraph Works. With regard to the supply department that is going on very satisfactorily. There was necessarily, during the year of which I am now treating, a large expenditure on that department to bring our stock up to the required amount. We have to maintain a large variety of different articles, which are required by our customers in all parts of the world. I do not believe that this outlay will be necessary in future years. As to our installation department, we have every reason to be satisfied. The business is largely increasing, and the character of our work is such as to do credit to us, and to secure confidence in us and our employers. A very important matter is that with respect to the Epstein accumulator. I hope you will consider it a proof of the discretion of the Board that out of the four inventions which we had under examination and testing, we accepted finally only one. We are not plunging into purchases or dealing with inventions which we are not convinced are likely to yield us profitable returns. We have had the Epstein accumulator under observation and testing for two years, and the result is as satisfactory as could be wished. We did not enter into any obligation with respect to this until we were satisfied that it was most efficient; that it opened a new field for traction purposes; that as regards efficiency and economy, it was superior to anything that existed, and also that we were perfectly secured in regard to it. We had the authority of four or five of the most eminent patent agents and leading counsel before we entered into an arrangement for the Epstein patent, in which we believe we have a most valuable property. The balance-sheet gives you an unexaggerated and fair statement of what we have done, and I may say that I have every reason to expect that our next year will be at least as good as the past year, or even better. He concluded by moving the adoption of the report and accounts.

Mr. PHILIP RAWSON, J.P., seconded the motion.

Mr. DIXON maintained that a larger amount ought to have been written off for depreciation of patents, which, he pointed out, were constantly being superseded by other inventions, and which therefore did not really have 14 years' "life." He did not think the 10 per cent. which was allowed last year was too much for the purpose. He objected to the £10,000, which was carried last year to goodwill account as reserve, being now "lumped" together with the rest of the reserve. Not a penny had been allowed for depreciation of goodwill. The Chairman had informed them that the investments were all right, but the shareholders had had no opportunity of judging for themselves whether that was so He had endeavoured to obtain information on the point, but had failed. He proposed an amendment adjourning the meeting for a fortnight to enable the Directors to consider these points, and whether the accounts could not be made more in accordance with what he called prudence.

Mr. BERBURY thought it would be better for the interests of the Company to carry forward more and to divide less.

Mr. W. GRIFFITH referred to the Auditors' certificate, and thought that the officials who had certified to the value of the stock investments, &c., should have their names put to the accounts in order that the shareholders might know who they were. He thought it a serious matter that their goodwill stood at £98,000 in the balance-sheet, which he presumed was the price paid in respect of it. He suggested that in future they should not extend their business so much by buying new patents and otherwise, and that they should get more established before pushing new business.

Mr. PEAKE said he could quite understand that it would be unwise to publish to the world the information respecting the nature of their investments; but he thought the shareholders would have much more confidence if they knew of what those investments consisted, and he thought they ought to receive information on this point if they applied at the offices.

Mr. S. S. BACON (Liverpool) said he had no idea of making any remark which should in any way disparage the valuable business of the Company, nor could he see how the shareholders would be benefited by refusing to pass the accounts at the present time. He perfectly agreed, however, with what had been said about the patents. He thought that more ought to have been written off the item, and he considered that it was "rather monstrous" on the part of the Directors in merging in the general reserve the £10,000 which was last year put to reserve for depreciation of goodwill. He also thought it was most unwise of the Directors to lock up the immense capital of the Company, as they appeared to have done according to the balance-sheet. They had locked up £93,000 in stock; and it looked to him, from the large amount of book debts, as if the Directors were rather financing their customers. Beyond this, there was the locking up of £119,000 in investments, of the nature of which the Directors did not inform the shareholders.

A SHAREHOLDER inquired whether he had understood that they were adding to the number of their patents from time to time at almost a nominal figure.

The MANAGING DIRECTOR, in reply, said that they had various foreign patents which did not expire in 14 years, and if they wanted to get the benefit of this longer term of years it was necessary to take out some of them before they took out the English patents. In this way they got an extended term. They had a large number of new patents continually taken out by their staff; these patents were the property of the Company, and they were shown in the balance-sheet at the cost of registration only. From time to time their patents thus became more valuable instead of less; but before long he hoped this item would be cleared off, and that they would have valuable patents standing in their balance-sheet at a nominal amount. They could not test the value of their goodwill in the first year, and therefore they put a large sum to special reserve. Now, however, the value of the goodwill had been proved. What he believed the Directors intended, and what his advice would be, was to write off the goodwill when the reserve fund amounted to a sufficiently large sum. They held the certificates of the officials who had certified to the values of the plant, &c.; and in regard to Auditors whom they had had to employ, his instructions had been to cut down the plant and stock as low as was possible. With reference to the new business, it could not be expected to pay in the very first year. The expenditure in connection with such business might have been spread over a series of years, but they had written off every penny. With reference to the investments, one of the shareholders had called on him the previous day to whom he had shown the list; and if the other gentleman who had spoken on this point would call at the offices he would be happy to show him the investments in the same way. Mr. Dixon could also see the investments.

A SHAREHOLDER: Why not show them to all the shareholders?

A SHAREHOLDER: There would be no certainty that the information might not be used against the Company.

The MANAGING DIRECTOR, continuing, stated that in the supply department it was necessary to keep a very large amount of stock. He thought it a good idea that the heads of the different departments should be made responsible for their stocks. The thing he was most anxious about was that the heads of the departments did not over-value their stock and plant; and as long as he was on the Board he thought the shareholders might rest assured with regard to this point. They were only on the eve of what they believed to be an immense extension of electrical work, and in order to be in the van and take part in this they must be able to supply largely all sorts of things.

The CHAIRMAN then put the amendment, which was lost by an overwhelming majority, only four hands being held up in its favour; and subsequently the original motion was carried.

Resolutions were afterwards passed declaring the dividends recommended, and re-electing the retiring Directors and Auditors.

On the motion of Mr. BACON, a vote of thanks was passed to the Chairman; and the proceedings then terminated.

Blackpool Electric Tramway Company (Limited).

The following is the report of the Directors for the year ending 31st October, 1891, to be presented to the shareholders at the seventh annual general meeting, to be held at the Victoria Schools, Tyldesley-road, Blackpool, to-morrow (Saturday), at 3 p.m.:—

The revenue account shows a balance in hand for the year of £3,049 2s. 6½d. Adding to this £184 17s. 7½d. from last year makes an available amount of £3,234 0s. 2d., of which the Directors recommend the following disposal:—

	£	s.	d.
Dividend of 7½ per cent. on the called-up share capital, free of tax	1,501	17	6
Depreciation and reserve fund	1,500	0	0
Balance to next year's account	232	2	8
	£3,234	0	2

The depreciation and reserve fund, with the addition of £1,500 as above recommended, will be £6,069 4s. 8d. The number of passengers carried this year was 933,652. The number of miles run during the year was about 98,000.

The retiring Directors are Messrs. Horsfall, Bickerstaffe, and Broadbent, who are eligible for re-election. Mr. Broadbent's services as Managing Director have been secured again for the coming year.

The transfer books of the Company will be closed from the 12th to the 21st November, inclusively.

Swan United Electric Light Company (Limited).

The following is the ninth annual report of the Directors of this Company, to be presented at the ordinary general meeting to be held at the Cannon-street Hotel, E.C., on Tuesday, the 24th inst., at 12 noon:—

The accounts are for the year ended September 30, 1891. After paying all current charges, and making due allowance for depreciation, there is a credit balance of £47,490. 11s. 2d. The Directors recommend that out of this balance a dividend of 11 per cent. for the year be declared; an interim dividend at the rate of 6 per cent. per annum, amounting to £11,104. 0s. 5d., has already been paid in respect to the first half of the year; the balance of the 11 per cent. for the entire year to be distributed in accordance with Clause 77 of the Articles of Association, and to be payable on December 1, 1891. This will absorb £28,376. 6s. 11d., and leave £8,010. 3s. 10d. to be carried forward.

The decision of the Supreme Court at Leipsic, in the patent cases which the Allgemeine Electricitäts Gesellschaft brought against the Company and their agents, has been given in favour of the Company. The Directors are now engaged in the consideration of the best way to take advantage of the favourable position thus created in Germany. The Compagnie Générale des Lampes Incandescentes in Paris have been in litigation as to their patents throughout the year. The experts to whom the Court referred the case have not yet rendered their report to the Judges, and until this is completed the Court cannot adjudicate on the case. The Compagnie Générale does a considerable amount of business, but competition is very keen on the Continent, and the selling price of the lamps is much reduced.

The Director who retires by rotation is Mr. J. W. Swan, who being eligible will offer himself for re-election. Messrs. Welton, Jones and Co., the Auditors, will also retire, and will offer themselves for re-election.

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NEW COMPANIES, STATUTORY RETURNS, &c.

CENTRAL AMERICAN MINT (LIMITED).—This Company has been registered by Hays, Schmettan and Co., 31, Abchurch-lane, E.C., with a capital of £125,000, in £10 shares. Objects: To carry into effect an agreement made November 6th between Wm. Elmore of the one part and A. Stevens, on behalf of this Company, of the other part, for the purchase of a concession granted by the Republic of Salvador for the purpose of establishing a mint and to carry on in all their respective branches the businesses of coin and metal manufacturers, engineers, boiler-makers, wire-drawers, metal workers, &c.

DALZIEL'S NEWS AGENCY OF AMERICA (LIMITED).—This Company was registered on November 14, 1891, with a capital of £100,000 in £10 shares, by Messrs. Burton, Yeates and Hart, solicitors, 23, Surrey-street, W.C. The objects are: To enter into an agreement with Dalziel's Cable News Agency (Limited) for the acquisition of such part of their business as is now carried on in the United States of America, to carry on within the limits of the United States, but not elsewhere, the business of an agency for the receipt and supply of news and information of all kinds, and to carry on the business of advertising agents, newspaper proprietors, printers, publishers, newsagents, and stationers, and of a telephone, telegraph, and electric light, heat and power supply, and pneumatic despatch company, in all or any of its branches. The number of Directors is not to be less than two or more than seven, the first being D. Dalziel (Managing Director), W. C. Hallett, H. F. Jackson, and H. King. Qualification of Director, £100.

IMPROVED GALVANIZING COMPANY (LIMITED).—This Company has been registered with a capital of £75,000, in 2,500 £10 preference shares, 4,950 £10 ordinary shares, and 500 £1 founders' shares. To carry on in the United Kingdom or elsewhere the business of manufacturers of iron, steel and other metals, whether coated with lead or otherwise, and of iron-founders generally, and also to acquire any patents, patent rights, &c., in relation to the above objects.

ISLE OF WIGHT ELECTRIC LIGHTING COMPANY (LIMITED).—This Company was registered on November 12, 1891, with a capital of £1,000 in £1 shares, by Messrs. Deacon and Co., 4, St. Mary-axe, London, E.C. The objects are:—To carry on business as electricians, mechanical and electrical engineers, workers and dealers in electricity, motive power and light, and to carry on the business of manufacturers of and dealers in machines, lamps, and other appliances for supplying light and power by means of electricity. The number of Directors is not to be less than two nor more than five, the first to be appointed by the subscribers to the Memorandum and Articles of Association.

NEW JERSEY IRON AND STEEL COMPANY (LIMITED).—This Company has been formed to acquire the old-established businesses of the New Jersey Steel and Iron Company, the Trenton Iron Company and Wire Mills, the Durham Ironworks, the Passaic Rolling Mills, and the Warren Iron Company. It has a capital of £680,000. The Duke of Marlborough is the Chairman of the London Board.

NEW MOTOR SYNDICATE (LIMITED).—This Company was registered on November 11, 1891, with a capital of £5,000 shares in £10 shares, by Messrs. Bedford and Co., 6 and 7, Great Tower-street, E.C. It purposes to adopt and carry into effect an agreement between T. C. Hersey and W. M. Knight, and dated August 12, 1891, and to acquire and develop certain patents, further particulars of which are not given.

RAILWAY ELECTRICAL FOG SIGNAL SYNDICATE (LIMITED).—This Company was registered on November 12, 1891, with a capital of £25,000, in £1 shares, by S. G. Warner, 6, Quality-court, Chancery-lane, W.C. The objects are:—To carry into effect an agreement dated October 7, 1891, made between W. Andrews of the one part and J. Press, jun., of the other part, for the purchase of the interest of W. Andrews in certain patents, Nos. 18,747 of 1889 and 14,181 of 1890, to carry on business as electrical engineers and contractors, to carry on the business of manufacturers of and dealers in electrical apparatus, and also the business of an electric light company in all its branches. The subscribers are:—A. Moore and J. Lewin, of Netherfield, Notts; W. Langsdale and S. P. Derbyshire of Nottingham; M. Gregory, of Bridgford, near Nottingham; G. Tutin, of Beeston; and F. H. Bedells, of Nottingham. The first Directors are to be elected by the subscribers. Qualification, £250. Remuneration, £500 per annum, divided between them. Solicitor, Arthur T. Ashwell, Nottingham.

REALIZATION LAND COMPANY (LIMITED).—This Company was registered on the 14th November, 1891, with a capital of £2,000 in £1 shares, to acquire and develop land, and to erect, maintain, and carry on waterworks, gas works, electric light, heat, and power, supply works, telephone works, &c. Registered by the solicitors, Messrs. Terrell, Atkinson and Winstanley, 33, Gracechurch-street, London, E.C.

SOUTH NORMANTON, BLACKWELL, AND HUCKNALL-UNDER-HUTHWAITE GAS COMPANY (LIMITED).—This Company was registered on 12th November, 1891, with a capital of £15,000 in £5 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are to light with gas, electricity, or other illuminating means, the towns of South Normanton and Blackwell in the county of Derby, and of Hucknall-under-Huthwaite, Notts.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The statutory return of the above Company, made up to October 29, 1891, was filed on November 12th. The Company was registered on July 11, 1891, with a capital of £800,000, divided into 40,000 ordinary and 40,000 preference shares of £10 each; and the first ordinary general meeting of its members was held at Winchester House, Old Broad-street, E.C., on October 15, 1891. 30,152 of the ordinary shares have been taken up, and upon 1,500 the full amount has been called and paid, while upon the remaining 28,652 ordinary shares £4 per share has been called and paid, the calls paid amounting in all to £129,608. The balance of the ordinary and the preference shares are at present unissued. Among the shareholders are Mr. T. Apfel (475 shares), C. Barclay, Lord Claud Hamilton, and J. B. Braithwaite (500 between them). The Brush Electrical Engineering Company, Limited (2,575), H. L. Bischofstein (1,000), Hon. Alan Charteris (100), R. Crawley (370), Baron Emile d'Eichthal (200), Earl of Dysart (168), T. A. Denny (1,000), Lord Nathan M. Rothschild (5,000), Earl of Suffolk and Berkshire (100), Sir David L. Salomons (200), Eustace Smith (500), P. G. B. Westmacott (500), Countess of Yarborough (400), Electric and General Investment Company, Limited (1,000), Laing, Wharton and Down Construction Syndicate, Limited (52), Colonel B. H. Martindale and Sir David Salomons, jointly (1,500), and Colonel B. H. Martindale (100). Registered offices: 1 and 2, Great Winchester-street, London, E.C.

CITY OF WATERFORD ELECTRIC SUPPLY COMPANY (LIMITED).—The first registered office of the above-named Company, which was registered on July 1st last with a capital of £1,000, in £5 shares, is situate at 11, Queen Victoria-street, London, E.C. (Filed on November 12, 1891.)

EAST LONDON ELECTRIC SUPPLY COMPANY (LIMITED).—The first registered office of the above-named Company, which was registered on July 1st last, with a capital of £1,000, in £5 shares, is situate at 11, Queen Victoria-street, E.C. (Filed November 12th.)

ELECTRICAL ASSETS PURCHASE COMPANY (LIMITED).—An agreement, dated November 5, 1891, between the Liepmann Carbon Company (Limited) of the one part and this Company of the other part, states that whereas by an agreement dated July 13, 1891, the Liepmann Company agreed to sell, and C. E. H. Hoskins, on behalf of this Company, agreed to buy, certain premises for the consideration of 500 shares of £1 each fully paid in the Assets Company; and whereas that agreement was ratified by the Company in general meeting on November 2nd. The 500 shares, numbered 1 to 500 inclusive, are to be allotted to the Liepmann Company or its nominees. The above Company was registered on July 28th last, with a capital of £1,000 in £1 shares, to purchase the whole of the assets and effects of the Liepmann Carbon Company (Limited), including its British and foreign patents for "Improvements in the manufacture of carbon for electric lighting." Registered office: Eastcheap-buildings, 19, Eastcheap, E.C.

ST. JOHN'S, HAMPSTEAD, ELECTRIC SUPPLY COMPANY (LIMITED).—The first registered office of this Company, which was registered on July 1, 1891, with a capital of £1,000, in £5 shares, is situate at 11, Queen Victoria-street, E.C. (Filed November 12, 1891.)

WYNDHAM ELECTRIC LIGHT COMPANY (LIMITED).—The statutory return of the above-named Company, made up to November 2, 1891, was filed on the 10th following. The Company was registered on July 6, 1891, with a capital of £1,500, in £1 shares, to purchase certain plant necessary for electric lighting, for W. Williams, of Treherbert, Glamorgan, and to light the village of Blaenrhondda by electricity. 585 shares have been taken up, of which 100 were issued as fully paid. Upon the remaining 485 shares 15s. per share has been called and £200 paid, including £19. 10s. paid in advance of calls, leaving £183. 5s. unpaid. Registered office: Old Bank-chambers, Market-square, Pontypridd, Glamorgan.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts of this Company for the week ended November 16th amounted to £819; aggregate receipts for half-year to date, £14,365.

ECONOMIC GOLD EXTRACTION COMPANY (LIMITED).—The Directors of this Company have issued a circular announcing that the syndicate alluded to at the last general meeting as being formed for the working of their amalgamators in South Africa is now fully organised, and that there seems to be a likelihood of a considerable demand for the machines made by the Company. It is also anticipated that the Company will shortly be able to deal with large quantities of tailings, which may be profitably treated by the Company's process.

MORECAMBE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The first statutory meeting of the shareholders of this Company was held on Monday evening, at the offices, Morecambe. Mr. G. R. Snowden presided. The secretary read a statement of the society's affairs, which was approved; and the Company's engineer attended with plan showing the position of central station and the main cables to be laid for supply. The provisional Directors were unanimously re-elected, with power to add to their number. The appointment of Mr. J. Duff as auditor was confirmed.

ORIENTAL GAS COMPANY (LIMITED).—At the meeting of this Company at the London offices on Wednesday, the Chairman, referring to the electric light, said that it had not at present obtained much of a footing in Calcutta. The Hooghly Bridge had been lighted with electricity, but it had not been a great success. Although they were constantly threatened with the production of electric light, he thought, in the face of an experience such as that to which he had alluded, they might be perfectly easy that for the present it would not materially interfere with their revenue.

REUTER'S TELEGRAM COMPANY (LIMITED).—A call of £2 per share on £3,500 new £8 shares is due to-day (Friday).

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WEST INDIA AND PANAMA TELEGRAPH COMPANY (LTD.).—The traffic receipts of this Company for the half-month to November 15th were £2,309 as compared with £2,602 in the corresponding period of last year, and show a decrease of £293.

WOODHOUSE AND RAWSON UNITED (LIMITED).—This Company are again applying to the public for further capital, and advertisements have appeared this week inviting subscription to 10,000 ordinary shares of £5 each (being the balance of 60,000 shares), upon which it is proposed to call up not more than £2. 10s. per share, and for 13,000 Seven per Cent. preference shares of £5 each, the latter being entitled to 7 per cent. preferential cumulative dividend per annum, together with 1 per cent. in every year in which the ordinary shares have received 10 per cent. dividend or upwards; also for 50,000 Five and a-Half per Cent. 1891 Debenture Stock, this being the balance of a total issue of £200,000, of which £65,500 is reserved for the payment off of a like amount of Six per Cent. Debentures outstanding; on this latter amount being paid off the Debenture Stock now issued becomes a first charge upon the entire undertaking. The time for sending in applications was up to and including yesterday (Thursday), and should this issue be taken up, the paid-up capital of this Company will amount to the large sum of £511,410, £146,410 of which ranks for a premium of 15 per cent. per annum (after the payment of 6 per cent. interest on the debentures, and 8 per cent. on the preference shares) for three years to July 1, 1892. The price of issue for the amounts now asked for is 5 per cent. per share premium on the ordinary shares, and the preference and debenture stock at par. From June, 1889, to June, 1891, the Company have duly paid 15 per cent. per annum on the ordinary shares, and the 8 per cent. per annum on the preference shares. We think that the balance-sheet issued by this Company would be more complete if fuller particulars were given as to the amount of plant and materials supplied to its numerous agents and the relation this amount bears to the sales effected by the various agencies.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. Nov. 11.		Price Wednesday, Nov. 18.		Rate per Cent. Yielded.	Dividend Due.	Business done during Week ending Nov. 18.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/6	Anglo-American	48½	49½	48	49	5 5 1	Jan., Apr., July, Oct	48½	..
£2,849,510	Stock	25/0	Do. Preferred	86	87	86	87	5 17 11	" "	87½	86¾
£2,849,510	Stock	5/0	Do. Deferred	12¼	12⅞	12	12½	..	" "	12¾	12⅛
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	..	..
130,000	£10	5/0	Brazilian Submarine	10½	11	10½	11	7 5 6	Mar., June, Oct., Dec.	11	10⅞
£69,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	135	140	140	145	4 16 7	April and October	143	139
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	10½	10⅞
6,000	10	10%	Do. Preference 10%	17	18	16½	17½	5 14 3	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3	3½	3	3½	6 13 4	April and October	..	..
6,000	5	10%	Do. Preference 10%	9½	10½	9½	10½	4 15 3	" "	10⅛	..
60,710	20	3/6	Direct United States	10¾	11	10⅜	10⅝	6 8 8	Jan., Apr., July, Oct	11	10⅛
400,000	10	2/6	Eastern	14	14½	13⅞	14⅛	4 12 0	" "	14⅛	14
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	14⅜	15½	3 18 8	" "	15¾	15
£1,209,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	106½	106
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅞	15½	14½	15	4 13 4	Jan., Apr., July, Oct.	15½	14⅜
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	106	109	106	109	3 13 5	February & August	107½	106½
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	102	105	102	105	4 15 8	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1900 (regd)	99	102	98	101	3 19 3	January and August	100⅛	100⅛
180,227	10	2/0	Globe Telegraph and Trust	9⅝	9⅞	9⅛	9⅜	5 8 10	Jan., Apr., July, Oct	9⅛	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15	14⅜	14⅝	4 0 8	" "	14⅛	14⅜
150,000	10	5/0	Great Northern	18½	19	18⅛	18⅜	4 10 8	Jan., April, and July	18⅜	18⅛
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	41	..
38,348	10	4/0	London Platino-Brazilian xd	6½	7½	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	7⅞	8½	7⅞	8½	4 16 11	April and October	7⅞	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	118	123	118	123	4 17 7	" "	..	..
15,609	10	6/0	West African Telegraph	7⅛	8½	7⅛	8½	5 17 8	January and July	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	97	100	96	99	5 1 0	March & September	..	..
30,000	10	2/0	West Coast of America	2	3	2	3	..	January and July	2⅜	..
£150,000	100	8%	Do. Debentures 8% 1902	97	102	97	102	7 16 10	June and December	..	..
88,321	10	9d.	West India and Panama	1⅜	1⅝	1⅛	1⅜	..	May and November	1⅜	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	8½	9½	8½	9½	6 9 9	" "	9½	9
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7⅛	8½	7⅛	8½	7 1 2	" "	..	..
61,683	15	9/0	Western and Brazilian	10½	10⅝	10	10⅛	7 2 10	" "	10⅝	10
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6⅜	7	6⅜	7	5 7 3	" "	6⅞	6⅛
30,364	7½	7/6	Do. 5 per Cent. Deferred	4	4½	3⅞	4½	..	" "	4½	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104	107	101	107	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	7/8	1/16	7/8	1/16	7 9 4	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/8	3/16	3/16	1/4	6 3 11	Yearly	..	..
438,984	5	3/6	National	4¼	4⅝	4⅜	4⅝	6 9 9	June and December	4 9/16	4 7/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13	12½	13	4 12 4	" "	13	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12	13	12	13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	100	108	106	108	4 3 4	..	107⅜	107⅛
58,000	5	1/0	United River Plate	1	2	1	2	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 Sh.)	prem ⅛	⅜	4⅛	4⅜	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
5,322	£5	..	House to House Electric	..	..	4½	5	..	..	..	..
30,000	£5	3½	Liverpool Electric Supply (£3 paid)	2⅜	2⅞	2⅜	2⅞	..	March and February	..	..
10,000	5	3½	Do. (fully paid)	4⅛	5⅛	4⅛	5⅛	..	" "	..	..
111,000	£5	..	London Electric Supply	1⅜	2⅜	1⅜	2⅜	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	10	10⅜	10	10⅜	..	..	10⅜	10⅛
6,318	10	..	Notting Hill Electric Lighting (£8 paid)	6	7	6	7	..	..	..	..
7,780	£5	3/6	St. James' and Pall Mall	8⅜	9⅛	8⅜	9⅛	..	..	9⅛	8⅞
..	..	7%	Do. 7% Preference	7⅞	7⅞	7⅞	7⅞	..	..	7 15/16	7 7/16
42,853	5	..	Westminster Electric Supply (£5 paid)	6	6¼	6¼	6⅜	..	..	6⅜	6⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/8	Brush Electrical Engineering	3⅜	3⅝	3⅜	3⅝	4 19 9	..	3⅝	3⅜
69,996	2	6%	Do. 6 per Cent. Preference	2⅜	2⅝	2⅜	2⅝	5 2 8	..	2⅝	2⅜
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5	5⅛	5	5⅛	6 7 3	January and July	..	..
17,130	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	6%	Electric Construction	6⅞	7⅛	6⅞	7⅛	..	..	7 1/16	6⅞
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅞	3⅛	2⅞	3⅛	..	..	3⅛	2⅞
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20½	21½	20½	21⅛	4 15 8	February & August	21⅛	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	6	7	6	7	..	January and July	..	..
11,334	£10	8/0	Do. Preference	8⅜	9½	8⅜	9½	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅜	⅝	⅜	⅝	..	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4⅜	5	4⅜	4⅝	8 2 0	May and November	4⅝	4⅛
37,350	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July	43½	42½
50,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2⅛	2⅜	2⅛	2⅝	15 15 9	..	..	..
..	£5	8%	Do. Preference (fully paid)	3⅞	4	3⅞	3⅞	10 0 0	..	..	..
			RAILWAYS AND TRAMAYS.								
£2,850	10	..	Blackpool Electric Tramway	..	..	..	..	..	..	..	..
60,000	£10	..	City and South London Railway	3	5	3	5	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

The meeting at the Mansion House on Wednesday last ought to prove of some use in giving the Electrical Exhibition at the Crystal Palace a good start. An imposing Honorary Council of Advice has been got together, by which we mean that their names are all in print. A few of them turned up at the meeting, where a fair representation of the scientific and the commercial interests was also to be found. A report was read which referred to "Electric Force," "The Infant Electra," &c., and alluded too briefly to the Exhibition which was held at the Crystal Palace in 1881. The Lord Mayor, in a speech which followed the reading of the report, was apparently unaware that a successful and useful Exhibition had already been held at Sydenham. He naturally complained about the dawdling way in which the City lighting is proceeding. Mr. Preece followed with his well-known plea that, if looked upon in the proper way, electric lighting is as cheap as gas. He alluded to so-called "international" Exhibitions, and remarked that the idea was dropping out of fashion, that "the forthcoming Exhibition would be national, and English engineers would have an opportunity of making comparisons without being affected by prohibitive tariffs." Since no Protectionist country can with any sense of decency hold an "international" Exhibition, the idea of *national* Exhibitions is well worthy of consideration. Those who wanted to know how German engineers carry out their work had only to go to Frankfort to see a thorough display, and any who want to see American machinery will never have a better opportunity than that which will be offered by the Chicago Exhibition. Mr. Preece suggested that an important application might be expected in the direction of the development of heat, which is now often produced by very objectionable methods. The Duke of Marlborough followed Mr. Preece with a rather long account of the lighting of the City, and endeavoured to make excuses for the delay. The Crystal Palace Company may be very thankful that the trade have consented to support the Show. If a short Act were passed permitting Exhibitions to be held only in Leap Year, there would be some chance that they would be worth visiting. A ten-year period, as suggested and commenced in 1851, would be better still. May we never have another this century!

There seemed to be some doubt at the Mansion House meeting whether awards or prizes would be offered. It is to be hoped that the farce of jury inspection and the solemn adjudication of utterly worthless medals will be dropped. It is true a dozen well-known men have been entrapped into acting as a "committee of experts," and that a committee of experts is an admirable idea. You have, all in working order, machines and apparatus, which are, at other times, either employed on public service or are in the workshops; and there is a lingering feeling that some wonderfully complete test of the efficiency of dynamo, lamp, motor, or transformer may at last be made without bias. There is, however, but little mystery now about these matters, and an Exhibition is one of the worst places for carrying out a test. Looking back on other Exhibitions, we can only recall the arc-lamp tests at Philadelphia, and Prof. Kittler's glow-lamp tests at Munich; there have been other investigations, but they have long passed into oblivion. Nothing, indeed, would be more likely to make the forthcoming Exhibition a prominent landmark in the history of electrical engineering than the properly-directed labours of a well-chosen committee of experts. It seems to be a splendid opportunity for doing something, but we regret that we cannot say what. A good suggestion or two appears to be urgently wanted. There is one difficulty in the way, probably the difficulty that has always proved the obstacle in similar cases—namely, such that good men as are fortunately to be found upon the present Committee are fully engaged, and have no time for exhaustive tests.

We have on several occasions referred to the remarkable work of Prof. Minchin in connection with the sensitiveness of impulsion cells to the action of light; and from a short article we publish this week it will be seen that some of these cells are in many ways well adapted to detect the presence of electric oscillations. Many of them are marvellously sensitive, one described in this issue being capable of distinguishing between the sounds uttered in pronouncing different letters of the alphabet. When used for the purpose of detecting electromagnetic disturbances, they act merely as relays, and in this respect have an advantage over the spark micrometer of Hertz, in which the energy of the indicating spark has to be withdrawn from the oscillations under test. While, however, Prof. Minchin may possibly be correct in assuming that the impulsion cell plays the same part as that of a Hertz resonator, his experiments do not amount to any proof. The resonator of Hertz is remarkable, not so much on account of its extreme delicacy, as for the fact that it responds merely to the alterations in the strength of the magnetic field in

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which it is placed; and the proof of this is afforded by its power of detecting nodes and internodes caused by the interference of the superposed oscillations. Not until the impulsion cells show a similar power can they be said to be capable of playing the part of HERTZ resonators, and even then the great care needed in handling them will prevent their use.

IN a recent letter to the *Western Daily Mercury*, Mr. C. H. RADFORD complains that the Plymouth district might now be enjoying an electric supply were it not for Clause 2 of the Electric Lighting Act of 1888. By this clause it is enacted that where any "undertakers" are authorised by Provisional Order or special Act to supply electricity within an area, any Local Authority within whose jurisdiction such area or any part thereof is situated may require the "undertakers" to sell at the end of the period specified in their authorisation, and the "undertakers" are thereupon obliged to sell, so much of their undertaking as is within such jurisdiction. Hence, although by the Act of 1882 no part of an area of supply need necessarily be comprised within the district of a Local Authority applying for a Provisional Order, a Local Authority can only exercise its compulsory purchase powers upon just so much of an electric-light supply system as comes within its borders.

"GREATER" Plymouth, it seems, possesses the privilege of being ruled over by no less than three distinct municipalities, so that the electric-light undertaking promoted by Mr. RADFORD could only obtain an Order covering the whole district on the condition that a central station was erected within the jurisdiction of each authority, since none of them wished to run the risk of having to purchase so many miles of unattached mains. Under these circumstances it was found impossible to proceed with the scheme. It may be remarked in passing that the London Electric Supply Corporation, although it has powers within the areas of some thirteen local bodies, has its generating station seven miles away from the richest districts supplied. Later on this fact may prove anything but an advantage. The Vestries may buy up the competing companies cheap and run their undertakings against the Deptford colossus. It is also within the bounds of possibility that the Deptford Local Authority, in a moment of public-spirited enterprise, might demand to have just so much of the undertaking as concerns it. On the other hand, should London ever be governed by one single municipality the relative position of affairs with regard to compulsory purchase would be reversed.

THE preliminaries of the attack on the LANE-FOX distribution patent are being arranged, and on Saturday last a motion on appeal from chambers for leave to amend interrogatories or something of that sort came before Mr. Justice ROMER. These preparatory preambulations are generally very dull, but there was a flash of "legal 'intelligence'" when a learned counsel began to instruct the Judge as to the use of mains. The Kensington and Knightsbridge Company use copper mains, but our readers may like to know how they are used. The current is generated in the supply station and is led by these mains to the lamps. "There it is partially consumed, but some comes back again by the conductor." This is really very interesting; we wonder what they do with this refuse waste current. Mr. PEMBER once said that the electric tramway companies made a cesspool of the earth; do the Kensington Company use these useless dregs of current that trickle back, "partially consumed" and scalded perhaps by the lamps, to flush the drains? So well managed a Company would not adulterate its freshly-generated current with such stuff.

Lambeth Vestry.—At the last meeting of this Vestry it was decided to apply for a Provisional Order.

Harwich.—At a meeting of the Town Council last week it was decided that the application for a Provisional Order should be persevered with.

Cable Extensions.—A duplicate cable, between Trinidad and Demerara, has been laid for the West India and Panama Telegraph Company.

Fareham.—Notice has been given by the Fareham Electric Light Company of their intention to apply for a Provisional Order for the supply of electricity for public and private purposes.

Halifax.—At a special meeting of the Town Council last week it was decided to apply for a Provisional Order to authorise the Corporation to supply electricity for public and private purposes.

Royal Society.—The following Paper was down for reading yesterday before the Royal Society:—"On the Electromotive Phenomena of the Mammalian Heart," by W. M. Bayliss and Dr. E. H. Starling.

Institution of Electrical Engineers.—On Friday, November 20th, a Paper was read before the students of the Institution on "Lightning Conductors and Guards," by Messrs. H. C. Haycraft and C. Minshall.

Proposed Extension of the City and South London Railway. Among the Parliamentary notices published in the *Gazette* is one on the part of the City and South London Electric Railway, to extend their system to Islington.

"L'Industrie Electrique."—It is announced by the *Bulletin International de l'Electricité* that a paper with the above title will probably shortly be started, under the editorship of M. Hospitalier, who will be assisted by the old *Electricien* staff.

The Thomson Meter.—The following figures are given of the number of Thomson meters manufactured:—On November 2, 1887, 680 meters; on the same date 1888, 2,680; 1889, 4,860; 1890, 10,000; and on November 2, 1891, 20,000 meters.

The Censorship of Telegrams in Brazil.—The Western and Brazilian Telegraph Company have received information that the Fiscals have been removed from all the offices in Brazil, and that there are now no restrictions on telegrams to and from that country.

Interurban Telephony in Holland.—The Dutch interurban telephone system will receive a considerable extension during the present month, when much more rapid communication than at present will be established between Amsterdam, Rotterdam, Utrecht, Haarlem, and other centres.

Pontresina.—The inhabitants of Pontresina recently formed themselves into a joint-stock company for the purpose of obtaining the electric light. Pontresina enjoys the advantage of possessing a 430ft. waterfall, so that some 500 H.P. is obtainable from a moderate supply of water.

Central London Railway.—At the last meeting of the Hammersmith Vestry the Works Committee reported that they had received an intimation from Messrs. John Aird and Son of their

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intention to sink certain trial borings in Uxbridge-road and Caxton-road, as a preliminary to the construction of the Central London Railway.

Paris Municipal Central Station.—Last week one of the pavilions at the "Halles" was suddenly plunged in darkness, owing to the breaking of a steam-pipe. Within an hour, however, the damage was made good and the light again switched on.

Direct Spanish Telegraph Company.—During the temporary interruption of the Direct Spanish Falmouth-Bilbao cable, arrangements have been made by which telegrams from Bilbao, Madrid, and all places in Spain, can, during the interruption, be promptly forwarded by the Eastern Telegraph Company's route.

Electrical Standardising, Testing, and Training Institution.—The management of this Institution announce that they award a Faraday scholarship of the value of 80 guineas a year, and a Maxwell scholarship of the value of 50 guineas a year, both tenable for two years. Entrance exhibitions, ranging from 20 to 40 guineas a year, may be awarded by the Council to unsuccessful competitors. The next examination commences on January 6, 1892.

The Blackpool Electric Tramway.—In our last issue we made some remarks with regard to the favourable showing of the electrical plant at Blackpool. The plant in question was supplied by the Electric Construction Corporation; and we learn on good authority that after working about six years the dynamos (equal to 50,000 watts) and the motors on the ten cars seem as efficient as when first laid down, and have given every satisfaction to the users.

Proposed Electrical Railway from Finsbury Park to the City.—Parliamentary notice has been given of intention to promote a Bill in the next Session of Parliament for powers to construct an electrical underground railway, commencing by a junction with the Great Northern Railway at Finsbury Park and terminating in the City about the centre of Finsbury-pavement. Powers will also be sought to run into and use the Finsbury Park Station of the Great Northern Railway Company.

Hove.—The Electric Light Committee of the Hove Commissioners report that, in answer to their advertisement inviting tenders for the supply of electricity, communications have been received from several companies, including the Brighton and Hove Electric Lighting Company, and Messrs. Crompton and Co. The committee recommend the Commissioners to enter into negotiations with Messrs. Crompton, as that firm alone has accepted in its entirety the scheme adopted by the Commissioners. The committee also recommend that the services of an electrical engineer be obtained.

The Chicago Exhibition.—The following list has been issued of the nations and colonies who intend to participate in the Exhibition, with the amounts of the appropriations officially announced:—Great Britain, £25,000; British Guiana, £3,000; British Honduras, £1,400; Cape Colony, £2,000; Trinidad, £2,000; Guatemala, £24,000; Honduras, £4,000; Argentine Republic, £20,000; Austria-Hungary, £33,600; Bolivia, £20,000; Brazil, £110,000; Chili, £20,000; Columbia, £20,000; Costa Rica, £10,000; Danish West Indies, £2,000; Ecuador, £25,000; France, £80,000; Germany, £50,000; Japan, £100,000; Mexico, £150,000; Nicaragua, £4,000; Peru, £20,000; Salvador, £6,000; Cuba, £5,000.

Sir William Thomson.—Some months ago, at a private meeting of Glasgow gentlemen, it was agreed to ask Sir William Thomson to sit for his portrait (in order that it should be presented to the University of Glasgow) as a mark of the respect in which he is held, in recognition of his invaluable contributions to science. It was at the same time determined that a replica should be presented to Lady Thomson. Mr. Herkomer was entrusted with the work, and the portraits have now been delivered. It has been arranged that the presentation shall be made by Mr. A. J. Balfour, who was an original subscriber, and is an old friend of Sir William Thomson's, on the occasion of his visit to the city for the purpose of delivering his rectorial address. Principal Caird will acknowledge the presentation on behalf of the University. The ceremony will take place in the Merchants' Hall to-day, at 12 o'clock.

Tiverton.—In connection with the electric lighting of the town, Mr. J. Siddalls, the borough surveyor, has presented a report, in which he briefly reviews the general question of town lighting throughout the country. Mr. Siddalls sums up in favour of the high-pressure alternating-current system. The report includes a comparison of the cost of the electric light and gas. Mr. Siddalls recommends the Town Council not to undertake the lighting themselves, but to advertise for offers from firms willing to take over the Provisional Order for a specified term, or, with the assistance of the Council, to establish a local company, to whom the powers of the Provisional Order could be transferred. Accompanying the report is a table, giving some particulars of the various municipal installations throughout the country. At the last meeting of the Town Council this report was presented and the recommendations for advertising for tenders was adopted.

Liverpool.—The Liverpool Electric Supply Company are about to make application to the Board of Trade for an alteration in the terms of their Provisional Orders. At present the more central portion of the city is included in an Order granted in 1889, one of the terms of which is that the Corporation shall be at liberty to purchase the undertaking at the expiration of 21 years, instead of at the end of the customary period of 42 years. The remaining portion of the city in which the Company have authority to supply is included in their 1891 Order. In the case of the latter Order the Corporation did not insist upon any alteration of the statutory purchase clause. The Company, under their sliding scale, now charge a maximum rate of 1s. per unit, and, having regard to the 21-year period in the 1889 Order, it is impossible for them at present to reduce this rate. The Order for which application is now being made places both areas under the same conditions as regards purchase, and reduces the maximum charge for electricity to 8d. per unit.

The Christiania Central Station.—As our readers are aware, the tenders for the central electric station in Christiania have been in for some time, and the decision will shortly be made known. It may be interesting to repeat the names (see *The Electrician* October 23rd) of the twenty firms who have sent in tenders, either for the whole of the installation or for parts. They are:—The Edison General Electric Company (New York), Crompton and Co., Siemens Bros. and Co., The Electric Construction Corporation, Callender's Bitumen Telegraph and Waterproof Company (for cables only), Siemens and Halske, Schuckert and Co., Thomson-Houston International Electric Company (Hamburg), Helios Actien Gesellschaft (Ehrenfeld-Cologne), Düsseldorfer-Ratinger Röhren-Kesselfabrik, Ratingen (for boilers only), Compagnie Continentale Edison (Paris), Mather and Platt (for dynamos, &c.), A. L. Thune (Christiania) (boilers—Babcock-Wilcox), Göhrig and Leuch's Kesselfabrik (Darmstadt) (boilers), L. and C. Steinmüller Röhren Dampf-Kesselfabrik, Gummersbach (boilers), O. L. Kummer and Co. (Niedersedlitz), Sharp and Kent, Woodhouse and Rawson United, J. and A. Jensen and Dahl (Christiania) (engines), Actien Gesellschaft für Chromakkumulatoren (Berlin).

Telephone Bills in Parliament.—The National Telephone Company will apply next Session for an Act authorizing them to erect and maintain wires for telephonic communication over streets and other public places, to break up streets, &c., and to erect posts on any street, or other place *within the United Kingdom*. Clauses will be contained in the Bill authorizing the Board of Trade or other public body, in the event of the refusal of the owner or occupier of any land or building to permit a wire or wires to pass over such land or building, to give the required permission; and to make provision "for the full and efficient formation and maintenance of telephonic communication upon such terms, and subject to such conditions, restrictions, and regulations, as may from time to time be prescribed by the Board of Trade or other public body, or local authority, or otherwise, as shall be provided by the intended Act." The New Telephone Company will apply to Parliament for a Bill conferring on them and any County Council

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or other local authority, powers to make agreements with respect to placing and maintaining posts, &c., in or over any public streets, and the opening up of streets, &c.

Coast Communication.—The following circular, sent us by Mr. J. Lawrence-Hamilton, M.R.C.S., late Honorary President Fishermen's Federation, may prove of interest :—

Including 58 signal stations, the United Kingdom has 680 coastguard stations and detachments (which, in case of war, will be increased by 78 extra stations) within a mile of a telegraph office. At present these 680 coastal stations are locally "near" to telegraph stations, open only from 8 a.m. to 8 p.m., and generally closed all Sunday. It appears that no information has hitherto been collected or published as to the distance of these coastal stations from local telegraph offices, open all day and all night, including Sundays. For defensive purposes during war, and to save life and property at sea, including stranded vessels, both during peace and war, each of these coastal stations should have its coastguards, now numbering 4,200 meu, taught and trained to work telegraph instruments, kept at each coastal station, open day and night without any intermission. These coastal stations should form a complete continuous telegraphic circuit round our coasts and islands, also communicating with lifeboat stations, and with inland telegraph stations, so as to keep the authorities and Lloyd's informed. For 1891-92 the surplus postal profits have been estimated at £3,371,000, part of which should supply the present deficient telegraphic British coastal communication. Even if such charges for a coastal service cost £100,000 or more yearly, the country must have it. However, probably a scheme could be arranged to make such necessary national improvements soon financially self-supporting. The following table shows that these 680 coastal stations are at varying distances, some upwards of 35 miles from the "nearest" local telegraph office, which offices are mostly open only from 8 a.m. to 8 p.m., and closed usually all Sunday.

Under	½	mile,	228	coastal	stations.	Under	15	miles,	29 coastal stations.
„	1	„	74	„	„	„	20	„	5 „ „
„	2	miles,	57	„	„	„	25	„	1 „ „
„	3	„	76	„	„	„	30	„	0 „ „
„	4	„	60	„	„	„	35	„	3 „ „
„	5	„	58	„	„	„	40	„	1 „ „
„	6	„	39	„	„				680
„	7	„	24	„	„				
„	10	„	25	„	„				

Science and Conjecture.—The following extracts from a very apposite article in the *Spectator* of Saturday last will be read with interest in view of recent *ex cathedrâ* deliverances :—"The scientific authorities of to-day have fallen into a rather provoking and tantalising habit of taking the public into their confidence, making known to it discoveries that are as yet only half known to themselves, and building upon the basis of those discoveries a bewildering fabric of conjectural possibilities as to the extraordinary phenomena that may result should the discoveries prove to be true ones. No doubt the really scientific man should have no difficulty in sifting what is actually true from what is only possible; but the unscientific host, to which we confess that we belong, is apt to get rather bewildered by such revelations, and, confusing science with pure conjecture, to believe in all manner of impossibilities and absurdities. For in these days the range of science is so enormously advanced and extended that one must either know a great deal or nothing at all. As it is the work of a lifetime to know a great deal, most people are fain to know nothing at all, and to put a blind trust in those who have the reputation of knowing more than they do. It is natural that the public should swing between too much credulity and too much unbelief. Part of the fault is, as we have said, owing to science itself, which is nowadays a great deal too prone to submit to us discoveries which are but half tested and proved, and to confuse our ignorant minds with wild conjectures. We are ignorant, it is true; but that is not altogether our fault, and we are really anxious to learn. It is annoying, when we are in so humble and expectant a state of mind, that science should dangle before our eyes the most dazzling theories, only to snatch them away again. These are the very 'fairy tales of science.' Let us be prudent; we will neither believe nor will we disbelieve; we will merely wait and see."

The Microphone "Interference" Case.—In a supplement to the *Electrical Engineer* of New York, of November 17th, it is stated that the Edison-Berliner Microphone "Interference" case to which we alluded last week, terminated that day in favour of Emile Berliner. The patent is entitled "Combined Telegraph and Telephone," and is numbered 463,569, and dated November 17, 1891. Berliner's application was filed June 4, 1877, and Edison's, July 20, 1877. In regard to these extraordinary "interference" cases, the *Electrical World* reports that at the next Session of Congress a Bill will be passed to expedite the decision of interference cases occurring in the Patent Office. "It has been obvious for some time," says our contemporary, "that some such step should be taken, for the reason that the procedure of the Patent Office has given great opportunity for abuses, a chance which has been taken advantage of in a large number of cases. The remedy proposed is a somewhat singular one, being nothing less than turning over the interferences to the Circuit Court within 60 days after they are formally declared. An appeal, of course, can be taken to the Circuit Court of Appeals. Under such an arrangement the responsibility would be shifted from the Patent Office to the Circuit Court, and the final decision would be subject only to such delays as generally pertain to cases before that tribunal. The proposition is a specious one, but we very much fear that the result will not be altogether satisfactory. The suggested arrangement will relieve the Patent Office of interferences, but whether it will be able to go further and relieve the public from the improper delaying of patents is quite another matter. In the hands of attorneys anxious for delay, as they would be when delay was to be the purpose of both sides, a case can be made to drag its slow length along for a very considerable period even now, and when the Circuit Court docket becomes crowded with interference cases facilities for killing time will multiply. It is a very difficult matter to hasten the settlement of such questions with entire justice to both parties; we incline to the belief that the proper way of securing this much-to-be-desired end is by changes in the Patent Office practice, rather than by referring the whole matter to the Courts."

Brighton.—As reported in our last issue, the Town Council refused to purchase the goodwill of the Brighton Company's undertaking for £7,000. On the Lighting Committee's report being read, Alderman Sendall asked the Council to adjourn in order that they might discuss the question of the proposed purchase in committee. This motion was put and carried by 17 to 11 votes. The Council adjourned for about two hours, and on the readmission of the Press the Town Clerk said the following resolutions had been passed during the adjournment :—(1.) That the committee report to the Council recommending them not to agree to the purchase of the goodwill and undertaking of the Brighton and Hove Electric Light Company, upon the terms and conditions set out in the report of the Lighting Committee. (2.) That the committee recommend the Council to direct that application be made to the Local Government Board for sanction to borrow a sum of £8,500 for a period of 30 years for purposes of the electric lighting undertaking. These resolutions were carried. —In a letter to the *Sussex Daily News* of Saturday Mr. R. Ballard states that the reasons which led the Council to this decision were :—(1.) That the Council does not approve of paying any money, large or small, to the Company for goodwill or any other purpose. (2.) The Lighting Committee is turning away customers in the streets in the authorised area, but for which they have no funds to supply with cables. In this state of affairs it is not advisable to take over an additional business. (3.) That to take over the Company's business, especially in the outlying districts, would involve an immense capital on the low-pressure system, to which the committee appears up to the present to be wedded. Mr. Ballard urges that an amicable arrangement (not a pecuniary one) should be come to, allowing the Company some degree of permanence in the outlying districts, and some concessions in the authorised area. There would then be two *fairly* competing systems; the price of supply might be agreed on, and the merits of high and low pressure would be tested side by side.—"On grounds of expediency, as well as those of common justice," says the *Sussex Daily News*, "the decision of the Brighton Town Council, on Thursday, with regard to the proposal for purchase of the goodwill of the Brighton and Hove Electric Lighting Company's business is regrettable. . . It is sought to induce the Company to go on doing the unprofitable business, so that directly any portion of it becomes profitable the Corporation may step in and assume it. We have no hesitation in saying that this is neither just nor honourable."

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DETECTION OF ELECTRO-MAGNETIC DISTURBANCE AT GREAT DISTANCES.

BY G. M. MINCHIN.

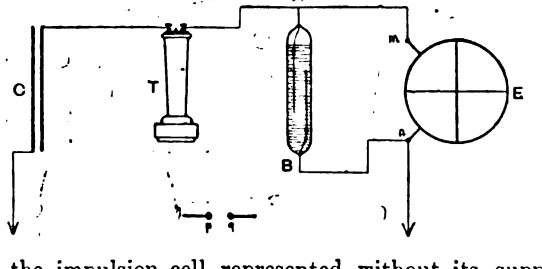
In the *Philosophical Magazine* for last March* I published a Paper giving an account of my work in Photoelectricity; and in this Paper is a description of certain photoelectric cells, which I have called *impulsion cells*. These are small cells, in which the plate which generates the E.M.F. when exposed to light is a piece of tinfoil whose surface must be prepared in a special manner; the liquid in the cell is methyl alcohol.

The most minute mechanical disturbance given to the base or support of the cell will make it insensitive to light if it was previously sensitive, or sensitive if it was insensitive. The cell is connected with a quadrant electrometer, whose indications show whether the cell is sensitive to light or insensitive, without our being obliged to expose the cell actually to light.

In the Paper above mentioned I have stated that when such a cell is in the insensitive condition it can be rendered sensitive by the inductive action of the sparks of a Voss machine or of an induction coil (the cell being shut up in a dark box), and that the induction coil was found to be effective in altering the cell when the distance between them was as much as 81ft. Last September I made a further series of experiments of this nature, and I found that if the coil was removed to a distance of 130ft. from the cell, the sparks were sufficient to make the cell sensitive to light if it had been previously made insensitive by any means. The coil was worked by a few Grove cells, and there was a clear space of 130ft. between it and the cell, no wires intervening. When the distance was increased to 150ft. it could be seen that the sparks held the cell in check, when the latter was started on its insensitive march, but at this distance the inductive effect was not quite sufficient to make the cell actually sensitive.

The cell which I used is one which is rendered insensitive by very minute disturbances. If a puff of air is sent from the lips to the base of the cell, or if the letter *p* is pronounced near it, the cell becomes insensitive. If we repeat to the cell the words "the King of Moab, then, was Balak, the son of Zippor," no effect is produced on the cell until the syllable *por* is pronounced, and then the cell becomes insensitive to light. Indeed, the word *Balak*, if the *B* is pronounced somewhat forcibly, will often make the cell insensitive.

About a month ago I made an experiment which enables us not only to *see* but to *hear* the effect produced on this cell by the electro-magnetic action of the induction coil. It is this experiment which I now desire to make known. The following figure represents the essential features of the arrangement.



I is the impulsion cell, represented without its support (a wooden clamp), its poles, A B, being connected with the poles, *m n*, of a Clifton-Thomson electrometer, E. The pole A is also connected with one pole of a telephone, T, whose second pole is connected with one pole of a condenser, C, the second pole of the condenser being to earth. The pole *n* of the electrometer is also to earth. Finally, *p q* represent the knobs of a distant induction coil.

Now if, either by talking to the cell or by touching its support with a feather, we make it insensitive to light, and then allow it to charge the condenser for a few seconds, on putting the telephone to the ear, and causing the spark to pass between *p* and *q*, we hear a sharp click in the telephone at the instant at which the state of the cell is altered by the electro-magnetic induction.

* See also *The Electrician*, Vol. XXVI., January 23, p. 361.

In the room in which I am working the distance between the cell I and the knobs *p q* is about 14ft., and the click produced by the sudden change in the cell is heard a small fraction of a second before the external sound of the spark travels to the ear.

I have observed these effects even when the distance between the knobs *p q* is less than one-thousandth of a millimetre.

Of course, it is clear that in many respects the part played in these experiments by the impulsion cell is the same as that played by the *spark micrometer* in the experiments of Hertz. (*See* Dr. Fleming's work, "The Alternate-Current Transformer.") But the distances at which the impulsion cell is sensitive to the sparks of the coil are many times greater than those at which the spark micrometer is affected.

As regards the capacity of the condenser, C, which will enable us to hear the click in the telephone, I have found that a condenser of very small capacity will not do—*e.g.*, one formed by two sheets of tinfoil on opposite sides of a plate of glass; but there is not much difference in the sounds produced by a condenser of capacity ·05 and one of capacity 1 microfarad. Also, with some impulsion cells, although the electrometer enables us to *see* that they have been changed by the sparks, the sounds are so feeble that they can scarcely be recognised in the telephone—showing probably that the alteration of their molecular state is comparatively slow. With other cells the clicks are loud enough.

It may also be mentioned that the small sparks obtained from an ordinary electrical gas-lighter, although they are almost surrounded by metal, have been found capable of changing the state of an impulsion cell at a distance of nearly 20ft.

Within the last few days I have made the following most important observation with an impulsion cell. If a Leyden jar of large capacity, or a battery of jars, is connected with the poles *p q* of the induction coil while the cell is in the insensitive state, and if now the spark of the coil is made to pass between *p* and *q*, *no effect is produced on the cell*; but if the Leyden jars are removed, the cell is instantly made sensitive by the spark. This experiment shows that the quickness of the electro-magnetic oscillations is involved in the phenomenon; and to this point I am now devoting attention.

EXPERIMENTAL DETERMINATION OF THE RATE OF PROPAGATION OF ELECTRO-MAGNETIC WAVES.*

BY R. BLONDLOT.

The attempts made to experimentally determine the rate of propagation of electro-magnetic waves have not, we know, attained much success up to the present. I have succeeded in effecting this determination by means of a new method, of which the following is the principle.

Since, as shown by MM. Sarrasin and de la Rive†, it is the resonator which determines the wave length observed, the equation $\lambda = V T$ should be satisfied if we substitute in it for λ and T the values of the wave length and period of vibration peculiar to the *resonator* employed, and for V the rate of propagation of the waves. The determination of this velocity resolves itself, therefore, into a determination of the period of the resonator and the wave length which it picks out. I gave the resonator a particular form in order to determine with certainty the exact period of its oscillations. I will describe one employed by me.

A condenser is constructed out of two circular plates, A′ A″ B′ B″ (Fig. 1), of 6cm. radius, and placed a fraction of a millimetre apart. These two plates are connected by the rectangular circuit A C D E F B, consisting of a copper wire ·184cm. in diameter. The side D E is 10·2cms. long, and the side C D is 6·3cms. long. The total length of the circuit, 32cms, is very small compared with the wave length. It follows that the oscillatory current has sensibly the same value in all parts of the circuit, and consequently we can here apply the formula given by Sir W. Thomson for the discharge of a condenser. More than this, since the current varies extremely rapidly we can, according to a note of M. Lippmann, neglect the resistance

* *Comptes Rendus*, Vol. CXIII., No. 19.
† *The Electrician*, Vol. XXIV., p. 316.

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and write $T = 2\pi\sqrt{CL}$; where C denotes the capacity of the condenser and L denotes the co efficient of self-induction of the circuit.

I measure C in electro-magnetic units by the classic method of Maxwell, and I determine L as follows:—The current may be considered as closed by the dielectric displacement across the air space separating the two plates of the condenser. This current may be split up into juxtaposed linear currents. Let ds be the length of an element, and i the strength of one of these currents; let ds' and i' be the length and strength of another element, r the distance of these two elements, and ϵ their angle. The potential of the total current is

$$\iint \frac{i\, i'\, ds\, ds'\, \cos\epsilon}{r},$$

this sum, including all the linear elements, constituting the total current. Hertz has, moreover, experimentally shown that the current is entirely localised on the surface of the conductors. The above sum is easily calculated by means of a formula given by M. H. Poincaré.* Having C and L, I deduce the period T.

It only remains to measure λ. As MM. Sarrasin and de la Rive† have shown that λ has the same value in air as in metallic wires, it was permissible to employ this last mode of propagation. By means of my resonator, which is for this purpose provided with a spark micrometer, consisting of a ball soldered to one plate and of a point fixed to the other, and regulated by a screw, I sought the position of the nodes and ventral segments along two wires, M N M′ N′ (Fig. 2), run parallel to each other, as in the experiments of MM. Sarrasin and de la Rive. The resonator shown at P Q is placed so that the long sides of the rectangular circuit are in

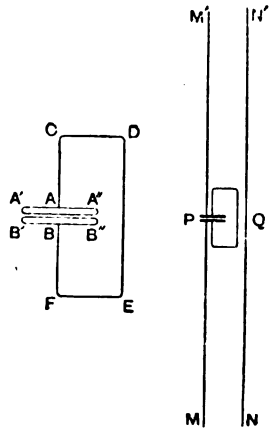

Fig. 1.

Fig. 2.

the same plane as the wires M N, M′ N′, between them, and parallel to them; each side is about ·5cm. distant from its respective wire. The distance between two consecutive nodes gives $\lambda/2$, and more generally the distance between two nodes which comprise n other nodes give $(n+1)\,\lambda/2$.

The following table gives the results of thirteen experiments:

Wave length in metres.	Velocity in kilometres per second.
8·94	299,300
10·90	300,500
11·04	304,100
11·58	301,400
11·60	302,000
14·32	300,800
16·20	298,700
18·30	300,700
18·32	293,400
22·68	288,300
25·72	295,800
27·28	292,700
35·36	291,400
	Mean...297,620

* *Electricité et Optique*, Vol. II., p. 156.
† *The Electrician*, Vol. XXVI., p. 701.

It can be seen that the values of the velocity are concordant although the wave length was varied fourfold. The concordance is as great as the precision of determination of the nodes allows. The experiments were made with resonators in which the dimensions of the rectangular circuit varied from 6·3 × 10·2cms. to 10 × 40cms., and the diameter of the wire from ·184cm. to ·3cm. These quantities have, therefore, no influence on the velocity, although the self-induction which depends on them varied in value from 246·66 to 973·2. We may conclude from the preceding that: *Electric undulations have only one rate of propagation independent of the wave length, and approximately 279,600 kilometres per second.*

The number determined is within the limits of experimental error equal to the ratio of the electro-magnetic and electrostatic electrical units, as is indicated by Maxwell's theory, and also to the velocity of light. It would be rash to conclude from this equality that electro-magnetic vibrations are of the same nature; nevertheless, we cannot ignore the fact that the result obtained is favourable to this hypothesis.

THE SIEMENS CABLE TRANSFORMER.

On the occasion of the reading of Dr. Fleming's Paper, "On some Effects of Alternating Current Flow in Circuits having Capacity and Self-Induction" before the Institution of Electrical Engineers in May last, allusion was made to some very instructive experiments which had taken place in April of the previous year at Messrs. Siemens Bros.' Works. A Siemens W

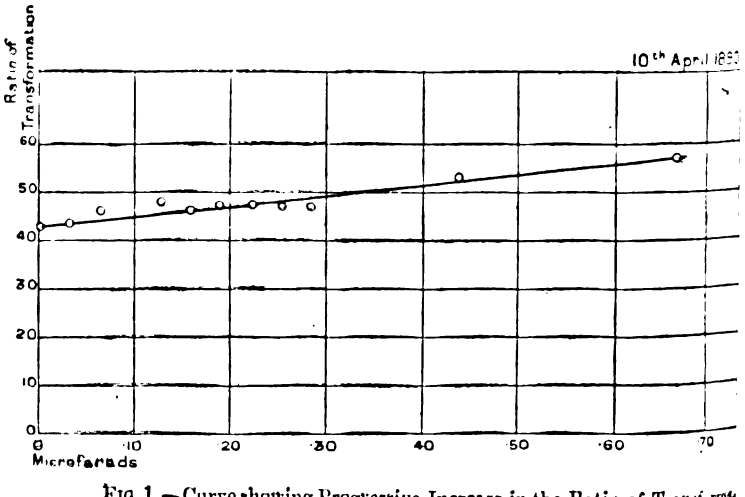

Fig. 1.—Curve showing Progressive Increase in the Ratio of Transformation of a No. 2 Siemens Closed-Circuit Transformer as the Capacity of the Secondary was increased.

alternator was run at constant speed and constant excitation, and connected to the thick-wire circuit of a No. 2 Siemens transformer, the fine-wire circuit of which was connected to a gutta-percha insulated single-conductor cable, the far end of which was free, placed in a tank of water. The length of cable in circuit was varied, and the resulting variations in the primary and secondary volts observed; and it was found that not only were the secondary volts three and a half times their normal value when a certain critical value was given to the capacity, but that the ratio of transformation *increased progressively* from 1:45 to 1:57 as the capacity was increased from zero to ·65 microfarad (see Fig. 1, reproduced from *The Electrician* of May 8, 1891). In the course of the discussion it was stated by Mr. Alexander Siemens that the particular alteration of the ratio of transformation referred to only applied to that particular type of transformer; and that his firm had found that if the form of transformer was altered the ratio of transformation remained absolutely the same, while the capacity of the secondary circuit was varied over a wide range. The transformer mentioned by Dr. Fleming was of the closed magnetic circuit type, and Mr. Alexander Siemens showed the curve (Fig. 2) deduced from experiments with an open-circuit "cable" transformer, from which it can be seen that the ratio of transformation remained constant at 23·5 throughout. It must, however, be remem

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bered that the volts do not fail to vary, although their ratio may remain constant. In the curves of the primary and secondary pressures shown at the same time it could be seen that there were huge variations in each circuit as the electrostatic capacity was altered.

The Siemens "cable" transformer consists of a long core of wire rope, composed of soft iron wires, covered with a layer of specially-prepared insulating material, around which are wound two insulated conductors, forming one the primary and the other the secondary circuit of the transformer.

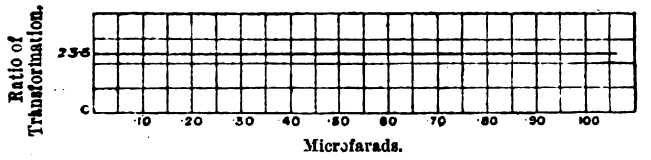

FIG. 2.—Siemens Open-Circuit "Cable" Transformer. Curve of Transformation Ratio when Capacity of Secondary is increased.

The illustrations (Figs. 3 and 4) show, in plan and elevation, a transformer of this construction coiled and fixed for use in a skeleton stand, with the terminals of the primary and secondary circuits arranged on the top. For various purposes,

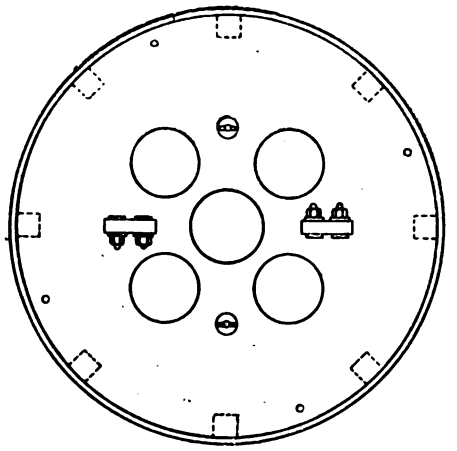

FIG. 3.—Siemens "Cable" Transformer. Plan.

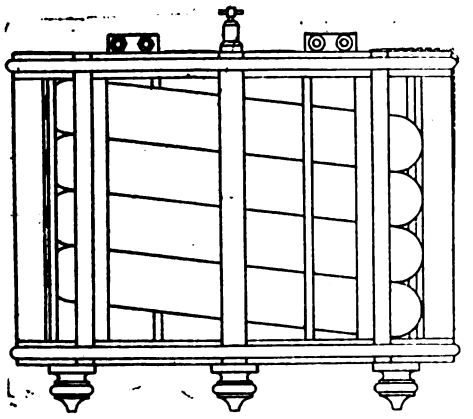

FIG. 4.—Siemens "Cable" Transformer. Elevation.

especially for central or sub-station work, it would probably be more convenient not to coil the transformers, but to lay them out straight or suspend them in a more or less horizontal or vertical position; but bending does not in any way affect their magnetic qualities. The dimensions of the iron core and conductors, and the quality of the iron, are so chosen that while the cooling surface of the transformer is much larger than in transformers of the ordinary type, there is very little heat generated by hysteresis, by eddy currents, or copper resistance. They, therefore, keep very cool, even when working at full load. They vary somewhat in efficiency, according to their size. They are, however, designed to work with a high efficiency at light loads, so that when they are used in central or sub-stations, or elsewhere, where the load is subject to great variations during the day, their average, or all-day, efficiency shall be as high as possible. For example, the 150 H.P. transformer would have 94 per cent. efficiency at full load, between 93 and 94 per cent. at half load, and 90 per cent. at a quarter load. Moreover, they are self-regulating, as regards their terminal pressure, within 3 or 4 per cent. of the normal pressure. The transformers are designed to transform from 2,500 to 100 volts, or *vice versâ*, and for a frequency of 100 ∿ per second.

Output in horse-power.	Weight of transformer, including skeleton stand.
10	5½ cwts.
50	13½ „
100	22½ „
200	42 „

BOOKS, &c., RECEIVED.

"Recenti Progressi nelle Applicazioni dell' Elettricità." By Prof. Rinaldo Ferrini. Vol. I., "The Dynamo." Second Edition, completely revised. (Milan: Ulrico Hoepli.)

"A Practical Guide to the Testing of Insulated Wires and Cables." By Herbert Laws Webb. (London: E. and F. N. Spon. New York: D. Van Nostrand and Co.)

"Catalogue of the Michigan Mining School." (Michigan: Published by the Mining School.)

"Electricity Treated Experimentally." By Linnæus Cumming, M.A. Third Edition. (London: Longmans and Co.) Price 4s. 6d.

"Popular Electric Lighting." By Captain E. Ironside Bax. (London: Biggs and Co.) Price 2s.

"Professional Papers of the Corps of Royal Engineers." Edited by Captain W. A. Gale, R.E. Vol. XVI. (Chatham: Institute of Royal Engineers.)

"The Mechanical World Pocket Diary and Year Book for 1892." Thoroughly Revised. (Manchester: Emmott and Co.).

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, November 27th. (To-night.)

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read:—"Modern Railway Carriages." By Walter Clemence, Stud. Inst. C.E.

JUNIOR ENGINEERING SOCIETY.

8 p.m. Presidential Address by Sir E. J. Reed, F.R.S., M.P.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Ladies' Night, Concert at St. James's Hall Restaurant.

MONDAY, November 30th.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Conversazione.

TUESDAY, December 1st.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Papers to be further discussed:—(1.) "Portland Cement, its Manufacture, Use and Testing. By H. K. Bamber, F.I.C. (2.) "The Inspection of Portland Cement for Public Works." By A. E. Carey, M. Inst. C.E. (3.) "The Influence of Sea-Water upon Portland Cement, Mortar, and Concrete." By William Smith, M. Inst. C.E.

WEDNESDAY, December 2nd.

SOCIETY OF ARTS.

8 p.m. Ordinary meeting. Paper to be read:—"Secondary Batteries." By G. H. Robertson, F.C.S.

THURSDAY, December 3rd.

CHEMICAL SOCIETY.

8 p.m. Ballot for the election of Fellows. Several Papers will also be read.

FRIDAY, December 4th.

INSTITUTION OF CIVIL ENGINEERS.

2 p.m. Students' visit to inspect the new Refrigerating Plant at Nelson's Wharf, Lambeth.

PHYSICAL SOCIETY.

5 p.m. Papers to be read:—(1.) "On a Permanent Magnetic Field. By W. Hibbert. (2.) "Note on the Production of Rotatory Currents." By Prof. Ayrton, F.R.S.

OLD STUDENTS' ASSOCIATION.

7:30 p.m. Smoking Concert at Mason's Hall Tavern

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ELECTRIC LIGHT AND EYESIGHT.

A short discussion has recently appeared in the columns of the *Morning Post* on the effect of electric light on the eyes. The first letter (on the 17th inst.) commenced with the very reasonable and proper statement that "the electric light is an admirable invention, but like many new inventions but very imperfectly understood." The correspondent continues to say that "unless electric light be softened by shades it is most injurious, and in cases of weak sight absolutely pernicious." Even this assertion is not too strong if it is taken as relating to the senseless way in which electric lights are too often placed. More than one case of this nature is described in vigorous language by Mrs. GORDON in her "Decorative Electricity," and some of her remarks were quoted in our review of that work (*The Electrician*, Vol. XXVI., p. 670). But the correspondent to the *Morning Post* should remember the advice given by a well-known judge to a junior: "Give your opinion, it will probably be right; reserve your reasons, they are sure to be wrong." He goes on to say that "if electric light be placed high, as it is in most houses and theatres, it should never be used at full power unless completely softened by shades of yellow, green, or blue." This suggests that there is something injurious in the nature or quality of the light, and that tinted shades will cure this evil. Red or pink shades are apparently excluded, and we have therefore no hesitation in putting down this correspondent as a member of the unfair sex. Rosy shades may sometimes be tawdry or even meretricious; but, when they allow enough light to pass they produce no disagreeable result, and they offer certain advantages on which it is unnecessary to dwell. But it is just in those cases in which the lamps are high, that the use of shades is less valuable. With the exception of an arc or a lime-light, no lamp has so great an "intrinsic brightness" as a glow-lamp giving its full candle-power. This simply means that the light-giving surface is very small. If lamps are arranged so that the filaments are visible, dazzling and dis-

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comfort will naturally ensue. One way out of the difficulty is to place them so high that the eye need rarely rest on them. The alternative is to screen them in those directions in which they may be seen. The word "shade" is used in a loose way, sometimes signifying such reflectors as are used over billiard tables, where the lamp is completely hidden; and sometimes, a translucent medium of glass or silk which is interposed to soften the light. If glow-lamps are placed high enough no softening is necessary, especially if light-coloured or white reflectors are used. If they must be placed low, the direct light must either be softened or completely screened. For reading, with a light set low, an opaque reflector or screen is essential, and yet how often is this common-sense precaution neglected! Any person of the most ordinary intelligence must see the folly of trying to read by a bright light close to the book, and without any shade, if they give the matter a moment's consideration. But no; they allow themselves to be half blinded, and then write to the papers. The arrangement of the lights in the Law Courts was criticized by another correspondent, who remarked that they are "hung so low and in such a manner that from the body of the Courts it is impossible to look at either the Bench, the jury, or the witness box, without having groups of lights shining full on the eyes." The lighting of the Law Courts was one of the earliest examples of illumination by glow-lamps, and there was little previous experience to go upon. The fittings are neat and in keeping with their surroundings, which is more than can be said for most of the "art" fittings of the present day. If the authorities will sanction a little re-wiring the arrangement might be considerably improved. The present defects are simply the fault of the man who, with pardonable inexperience, settled the positions of the lamps.

The correspondence to which we have alluded suggests that there is something aggressively pernicious in the nature and quality of electric light, and a most alarming and extravagant description was given of the well-known effects of arc lamps at close quarters on the eyesight of those who have to deal with them; and this was coolly put forward as "a statement which shows how great an abuse the electric light may become." Hundreds of our readers have, during their training, rashly exposed themselves to the light of arc lamps while engaged in testing or adjusting them; and though provided with dark glasses for actually inspecting the arc, have incautiously omitted to protect their eyes during their general work. Not much discomfort is felt at the time, but the sufferer generally begins to be aware of the mischief on going to bed; he has the sensation of sand under the eyelids. The pain is sometimes very severe, and sleep is often out of the question; but generally the irritation has passed off by breakfast time next morning, and the doctor is rarely consulted. But to bring forward this as a general argument against the use of electric light is arrant nonsense; and the exaggeration of the description given may be judged from the opening statement, "At certain works in France an electric arc is used which is more than equal to 100,000 candles." There is probably no arc lamp in existence giving more than 25,000 candles.

As far as the colour of electric light is concerned there is no quality or character that can possibly elude the analysis of the spectroscope. It would be possible to produce an apparently pure white light by mixing green and red or blue and yellow rays; and though apparently perfectly white, this light might tire the eyes by stimulating only a portion of the nerves. But the glow-lamp gives a light of precisely the same quality as a good lamp or gas flame, and the arc gives a more perfect, that is to say, a more nearly white light, but (*pace* the lamp makers) is not always perfectly steady. This brings us to a real defect which may occasionally exist, and one which has not, as far as we are aware, received careful attention. The light of lamps driven direct from small gas engines, without accumulators, is rarely steady. The irregularity has never, to our knowledge, been estimated except by the eye. A very slight variation, almost, or perhaps quite, imperceptible when looked for, may prove very tiring after an hour or two. It is highly improbable that there is any variation in the light of a glow-lamp corresponding to the frequency of an alternating current. There is certainly none that can be seen by mere inspection. A revolving mirror or a very delicate selenium photometer might settle the question by a physical measurement. A far more likely variation is that due to the beat of the engines.

Some physical measurements should be made in order to discover whether the light supplied by the leading companies is steady or not. The voltmeters give a satisfactory proof that there is nothing serious amiss; but the light of a glow-lamp varies one per cent. for a variation of one-fifth per cent. of the volts. If such a variation occurs at every stroke of the engine it would be practically imperceptible to the eye; and though not invisible on a good voltmeter, it could only be measured by special apparatus. The grumblers are in a very small minority, and it may be questioned whether it is worth while to make the investigation. The blinking which takes place on supply systems where alternators are not or cannot be run in parallel only takes place when it is necessary to change a main over from one machine to another. This is done so seldom in a well-regulated station that it need not be considered. We have never heard that the beats of the engines are visible on the glow-lamps; but it is quite possible that a variation may occur which is not directly visible, but produces some physiological effect which when prolonged may give rise to discomfort. This conjecture is thrown out in the endeavour to find some reason for these complaints. It is all very well for ignorant fault-finders, with their superficial chatter, to make irresponsible criticisms; but electrical engineers are even more ready to remove any defects than these prattlers are to sit in judgment.

REVIEWS.

A First Book in Electricity and Magnetism. By W. Perren Maycock. (London: Whittaker and Co. 1891.)

Were it not for the lists of questions following each chapter this would be an excellent elementary handbook for the general reader. As it stands, it must be considered as a text-book. We notice a rather neat analogy between electrical potential and wealth:—

"Let us consider a number of men. So long as every man had the same amount of money there would be no rich or poor amongst them. But directly one man got more money than any of the others, he would become rich as compared with them. On the other hand, if one of them parted with some of his share, he would become poor as compared with the rest. While every man has an equal amount of money, the idea of riches or poverty does not exist. When every body has its proper share of electricity, electricity is not apparent. When a man gets more than the average share of money, he becomes rich—his value is increased. When a body has a surplus of electricity, its potential is raised above the average, *i.e.*, above the potential of the earth. When a man parts with some of his money, he becomes poor—his value is decreased. When a body has less than its proper share of electricity its potential is lowered beneath that of the earth."

Few analogies will bear much pressing, but some of our readers may find amusement in considering the idea of argento-motive force, and in discovering financial analogues for self-induction and polarization.

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A Guide to the Unprotected in Every-day Matters relating to Property and Income. By a Banker's Daughter. Sixth edition, revised. (London: Macmillan and Co. 1891.)

It is not often that we have to notice a book written by a lady, and still more rarely one that is addressed to widows and single ladies. Neither technical education (of the scientific character to which we are accustomed) nor the experience of a pupil in engineering works teaches him how to draw a cheque, or what to do with a crossed one; and he will, as a rule, have much clearer ideas about slide valves than preference shares, knows more about commutators than mortgages, and would be much better able to execute a working drawing than a will. If he has no opportunity of picking up casual information he sometimes does not like to ask about "every-day matters," and even if he gets verbal assistance he cannot expect to get what this little book will give him, viz., between 50 and 60 specimen business letters. We have often consulted a previous edition of this book, and have found it to be of much more extended use than the very modest preface suggests. One excellent feature is that it begins at the very beginning, and no detail is considered by the authoress as unworthy of attention. The matters with which this little work deals come so naturally to commercial men that they generally have but little idea of the difficulty with which beginners learn them. The present edition is revised up to date; but we think that the scope is too modest, and that additional chapters should be given with extended information about promissory notes, and on the whole duty of an executor.

Pioneers of Electricity. By J. Munro. (London: The Religious Tract Society. 1890.)

The pioneers selected by the author are Thales, Gilbert, Franklin, Coulomb, Volta, Davy, Oersted, Ampere, Ohm, Faraday, and Maxwell. Brief biographical sketches, accompanied in most cases by portraits, describe in plain language the leading discoveries of these men, and some interesting incidents and anecdotes are given. It is pointed out in the preface "that seven of these investigators—that is, the majority—were disposed to cultivate the art of poetry."

Heroes of the Telegraph. By J. Munro. (London: The Religious Tract Society. 1891.)

Forming a sequel to "Pioneers of Electricity" this book contains some account of Wheatstone, Morse, Sir W. Thomson, Sir W. Siemens, Fleeming Jenkin, Reis, Graham Bell, Edison, and Prof. Hughes. In an appendix shorter notices are given of Gauss, Weber, Cooke, Bain, Werner Siemens, Latimer Clark, Du Moncel, and Elisha Gray. The author does not attempt to define a hero; and any heroic acts that may have been achieved by any of these men have not, so far as we know, or can learn from this book, any connection with telegraphy. The author's trouble in collecting these anecdotes and details might much better have been spent in searching for some of the unrecognised work of those who have toiled and received no reward. It is true that his account of Morse gives a fair share of praise to Vail, enough, indeed, to throw Morse to the background to no small extent. Mr. Munro tells us little, if anything, about these pioneers that enhances their already well-earned reputation; and we hope that he will some day give an account of the forgotten or too little appreciated work of men whose names are seldom mentioned; and that he will do for them what others have done for Henry, Sturgeon, and Gilbert.

Leitfaden zur Construction von Dynamomaschinen. By Dr. Max Corsepius. (Berlin: J. Springer. 1891.)

The calculations in this guide for designing dynamos are considerably obscured, firstly by being printed in some parts in two columns in order to save space, and secondly by the allowances for various losses being made simply by alterations in the original figures, no indication whatever being given as to the reason for, or mode of arriving at such alterations. This latter defect is sufficiently serious to make the reasoning perfectly unintelligible to anyone who has not sufficient knowledge of the subject to be able to do without a guide. A wiring table is given at the end of the book, but it presents no new features of any value.

SOME CURVES FROM ALTERNATING-CURRENT MACHINES.*

BY WARREN B. LEWIS.

The unusual number of experiments which have been made within a year or two upon the characteristic curves of currents as obtained from different types of dynamos, led the writer to attempt a few investigations in the same line, upon some alternating machines of special design. Taken in connection with preceding results, which have been published from time to time, they afford a most interesting study of dynamo-electric machines of this class, and give a more or less complete record of the peculiarities which may be obtained by different dispositions of iron and copper.

The applications of alternating currents to methods of heating, smelting, and other processes in which currents of immense volume are employed, has led to a class of apparatus considerably different from that which is so generally known and used for lighting. In the transmission of these currents obstacles have arisen which have been satisfactorily overcome only after considerable experimenting. The adaptability of the transformer to such processes has led to a large number of interesting experiments and developments, and has called for a dynamo to be used in connection with these transformers which possesses peculiarities not found in other types.

A combination of mechanical and electrical requirements has imposed conditions, some of which, if understood at the outset, may lead to a better comprehension of the results which follow.

In the construction of the transformer it has been found preferable, for many reasons, to make the secondary a large copper casting, which generally means a more or less solid mass of metal; but, in transmitting currents of several thousands of amperes, there is made evident the fact that the superficial area is of the greatest importance, and that the interior mass is of little use. This phenomenon being dependent largely upon the rate of alternations, the system could be made more efficient by using a low periodicity. The requisite induction in the armature wires can be obtained by causing a very rapid change in the magnetic circuit at some instant; and in the machines under observation this is so well done that only a remarkably small amount of wire is used. One would naturally expect that with an abnormal rate of change in the magnetic circuit at one point, a slower change would occur at some other place, and that the result would be a curve rather far removed from the typical sine curve. How closely the theory is proved by practice will be seen by reference to the curves.

The periodicity adopted was 50 per second, obtained from four and six pole machines. The two machines which were principally used in the trials are both six-pole, but of different designs as to the angular width of the pole pieces. The armatures of both are solid, with the exception of the ventilating holes, and have pole pieces corresponding to the field poles. The armature wire is wound in rectangular coils and put over the poles so as to surround them.

One machine, which will be designated as a "60," was a 60,000 watt dynamo of the composite type. A certain proportion of the armature current is commutated, and flows through the field wire in series with the current of a small exciter dynamo. The proportion commutated is dependent upon the ratio of the resistance of the exciting circuit to a shunt placed outside of the machine, and connected to a third collector ring.

Another machine was a separately excited dynamo, rated at 40,000 watts, and will be designated as a "40." This machine differs from the preceding in the angular width of the pole pieces and the shape of the grooves in the armature core. The third was a separately excited alternator, the armature having no iron, and will be designated as a "50."

In connection with each set of curves a small diagram is given, showing the relative dimensions of the various parts, and their angular positions. A description of the apparatus used is hardly necessary, as the same arrangements have been described in previous Papers. The galvanometer was a ballistic one, designed and constructed for the occasion, and gave excellent results.

In all the curves the abscissæ are actual degrees about the shaft of the machine, and ordinates the volts and amperes as marked. The position of the field poles with relation to the centre of the armature coil is also shown at the top and bottom of curves 1, 2, 3, 4, 5, 6, and by the dotted ovals in curve 7.

Curves 1, 2, 3 are of the type "60." The angular width of the pole pieces is shown in diagram 1 to be 40 degrees, and the space between them 20 degrees. The direction of rotation of the armature is indicated in each curve by an arrow.

In curve 1, the full line is the potential curve, the dynamo running on no load. The dotted curve is a sine, and is drawn to more forcibly illustrate the approach of the potential curve to a "saw tooth." The features which become noticeable are the regularity of the curve and its maximum E.M.F., which is about 468 volts: the working potential, as read on a Cardew voltmeter, being

* From the *Electrical World* (New York).

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296 volts, shown by a straight line. The field magnets required 386 watts, which were supplied by the small exciter alone, evidently.

Observe now curve 2. The dynamo is loaded on a water rheostat to a little over 52,000 watts, the field requiring 635 watts, or about

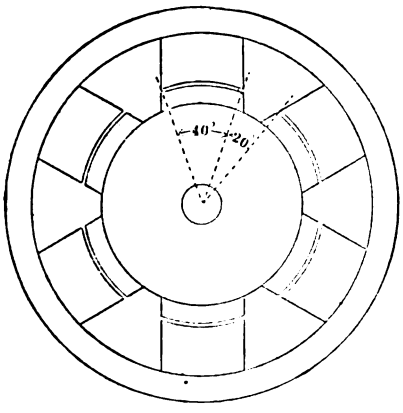
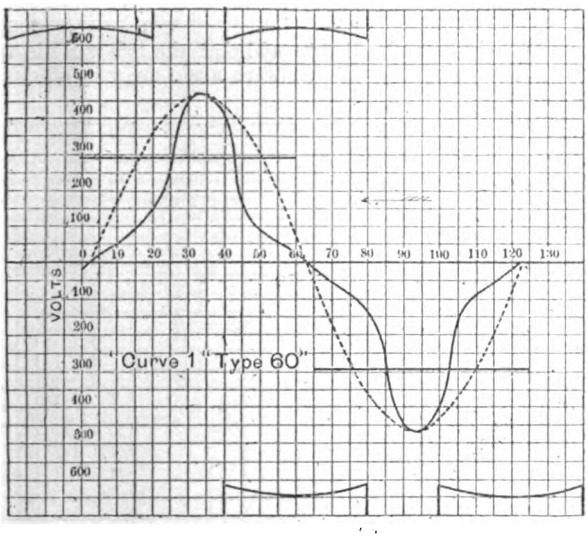
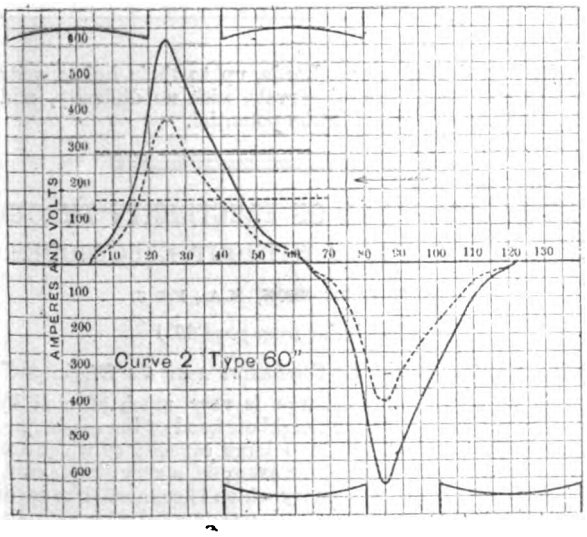


Diagram 1, "Type 60"

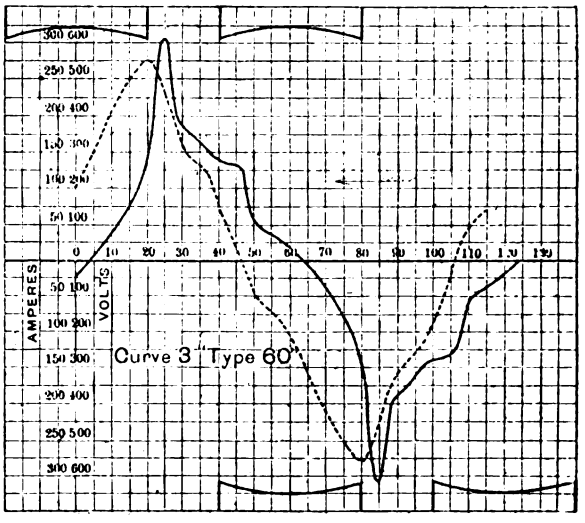
1·2 per cent. The regularity of the curve has been considerably disturbed, and the maximum point has reached 615 volts, while



the working potential has increased but 8 volts to 304. The dotted curve is the current curve, the straight dotted line the current as read on an ammeter, both drawn to the same scale as the potential curve. This makes rather a curious curve when compared with curve 1, but graphically illustrates the change in the magnetic



circuit very clearly—the sudden jumping away from the armature of the magnetic lines from the receding poles, and the leap to the armature of the lines from the approaching poles. But the peculiarity becomes greater when the load is an inductive one. Curve3 is such a load, the actual power being 34,500 watts. The maximum E.M.F. is the same as when a non-inductive load was used, and the side of the curve in the direction of rotation is not greatly changed; but the remaining part of the curve baffles



description. The current curve is quite regular, and approaches a sine curve, which is what an inductive load tends to produce, as is

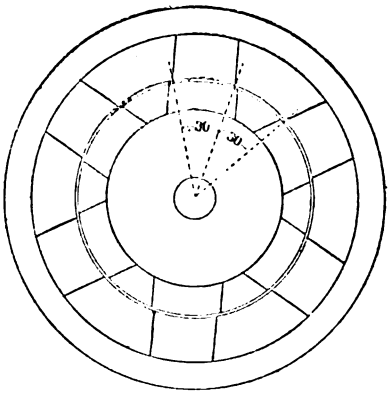
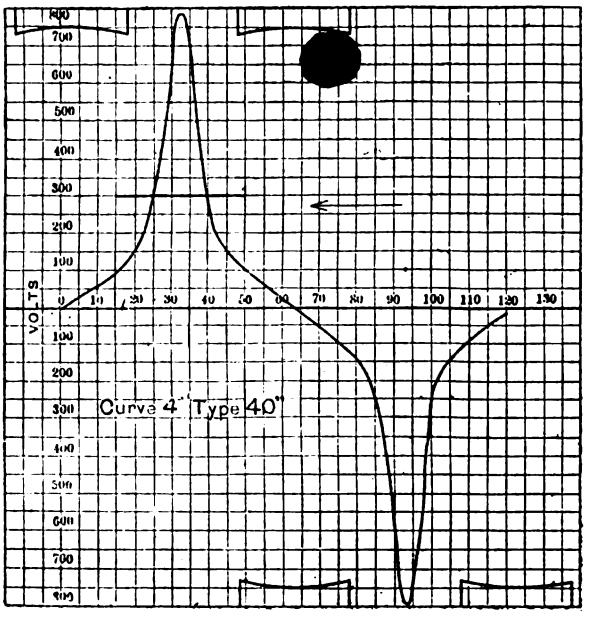


Diagram 2 "Type 40"

well known. The field magnets use 826 watts, or 2·4 per cent. of the output.



Referring now to curves 4, 5, 6, we see the effect of narrowing the pole pieces. This machine is the type "40," and the pole pieces, as shown in diagram 2, are but 30 degrees in width. The working potential being practically the same as in the case of the

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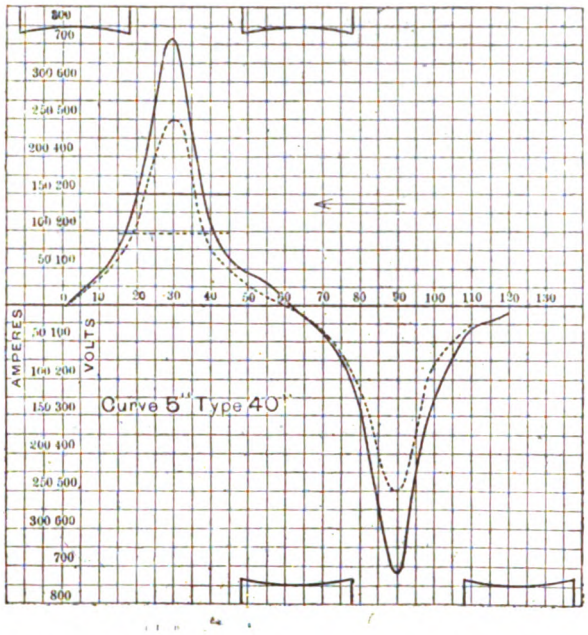
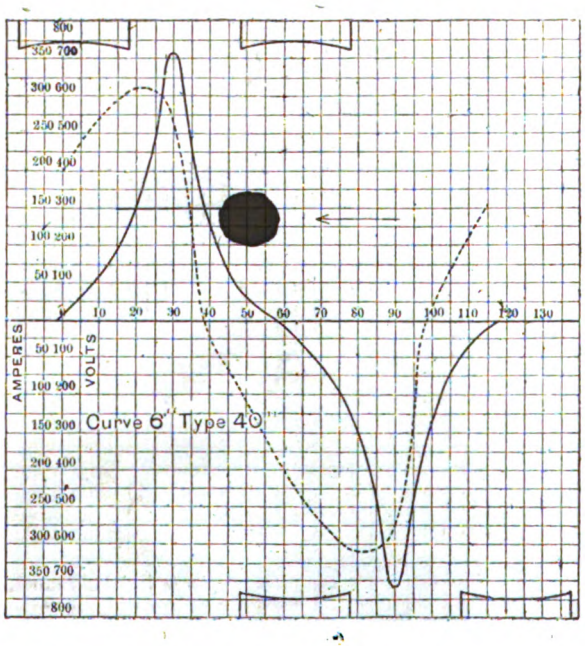
"60," namely, 300 volts, the maximum attained is 790 volts, with a position exactly midway between the poles, and very rapidly falling off, about equally on either side. It may be interesting to note the matter of insulation which this curve brings out. Although 300 volts is the working potential, the machine should be insulated for 800. As a fact these dynamos are now insulated to withstand a potential of 1,800 volts.

Curve 5 represents a non-inductive load of 34,000 watts, the fields using 936 watts. The angular position of the maximum point



has advanced, but the regularity is still preserved, with the exception of a few degrees near the zero line on one side. The curve has broadened, too, with a consequent drop in the maximum E.M.F. As would naturally be expected, the current curve follows the potential curve very closely. Curve 6 was taken when the dynamo was loaded with an inductive resistance, the same as in curve 3. The actual power was 37,000 watts, with 1,140 used in the fields. Notice that the current lags somewhat more than in the "60."



Curve 7 was made principally to show how far removed in character two machines of so different design could be. Diagram 3 shows the relation of armature and field, the dotted ovals being the field poles, and the full lines the armature coils. The dotted curve in curve 7 is a sine and serves to show how near the curve of the dynamo in question approaches it. Compare this with curve 4, and a greater difference could hardly be imagined.

Unfortunately, at this point, circumstances prevented the continuation of the experiments, and it is a matter of regret that further curves could not be taken on the last machine. A few rough experiments were made to determine the reaction of an armature pole upon a field pole, when the dynamo was carrying its full load, but the effect was so small that special arrangements would have had to be made, and for lack of opportunity the work was discontinued.

A very interesting study may be made by recalling the curves made by Messrs. Tobey and Walbridge,* on the "Stanley Arc Alternating Current Machine," and comparing them with those given in the preceding.

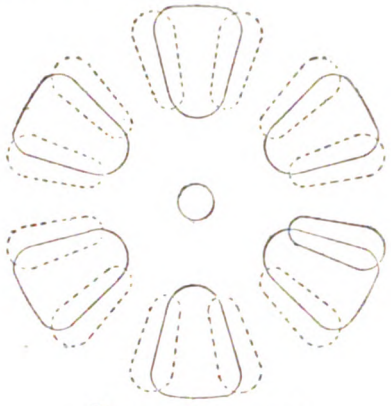
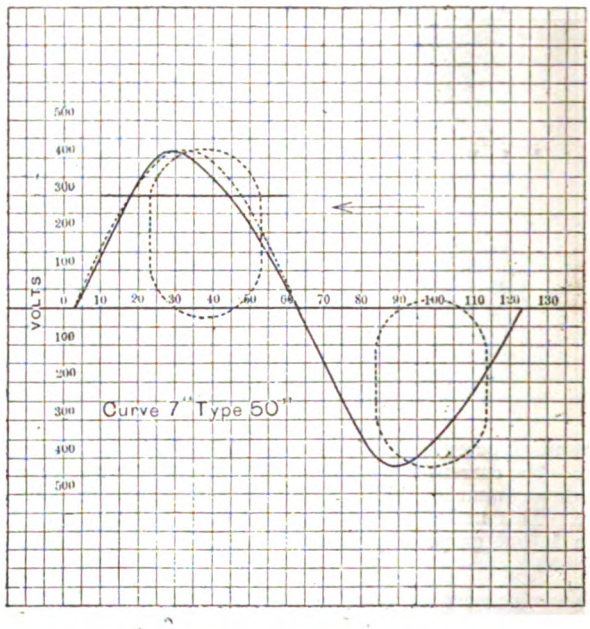


Diagram 3, "Type 50"

It may not be out of place to add that the two machines upon which the foregoing experiments were made are very efficient and



well suited to the purpose. Loads, up to their full capacity, are thrown on and off at brief intervals, with no difficulty, and with hardly a noticeable change in the potential.

ON THE DISCHARGE OF ELECTRICITY THROUGH EXHAUSTED TUBES WITHOUT ELECTRODES.†

BY J. J. THOMSON, M.A., F.R.S.

(Concluded from page 69.)

On the Effect produced by Conductors near the Discharge-Tube.

The intensity of the discharge is very much affected by the presence of conductors in the neighbourhood of the discharge-tube, especially conductors which have large capacity or which are connected to earth. Let us take, for example, a very simple case, that of a bulb surrounded by a primary which is connected to earth; in this case the approach of the hand, or any conductor connected to earth, will make the discharge brighter and at the same time less well-defined at the edges; touching the tube, though this is already connected to earth, produces a very marked effect in increasing the

* *See* the *Electrical World*, November 8, 1890.

† Abstract from the *Phil. Mag.*, October, 1891.

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facility of the discharge. We can, I think, understand the reason of this if we consider the behaviour of the tubes of electrostatic induction. When the spark passes, these tubes (see *The Electrician*, November 6th, p. 14) rush out from the jars and make for the primary; in their journey to the primary they pass through the bulb and produce the discharge. Let us suppose now that there is a large conductor situated somewhere near the bulb; the tubes, as before, rush from the jar to the primary, but in doing so some of them strike against the conductor; the tubes which do so lose the portion inside the conductor, acquire two ends each on the surface of the conductor. and swing round until they are at right angles to its surface; they remain momentarily anchored, as it were, to the conductor, and if the conductor is in the neighbourhood of the bulb, they will in general help to increase the maximum density of the tubes passing through the bulb. Though these tubes may not approximate to closed curves, and so directly produce a ring discharge, they may readily facilitate this discharge indirectly; for even those tubes which go radially through the bulb may produce a glow-discharge from the glass into the bulb, and may thus furnish a supply of dissociated molecules through which the ordinary ring-discharge can pass with much greater readiness. For nothing is more striking than the enormous difference produced in the electric strength of these rarefied gases by the passage of a spark. It is sometimes difficult to get the discharge to pass at first, but when once a spark has passed through the gas, a spark-length one quarter the length of that necessary to originate the discharge will be found sufficient to maintain it.

It is sometimes convenient, in cases where difficulty is found in starting the discharge, to avail ourselves of this property by connecting the mercury of the pump to which the tube is attached with one terminal of an induction coil, the other terminal of which is put to earth. When the induction coil is in action, a glow-discharge fills the pump and tube, and while this glow exists the

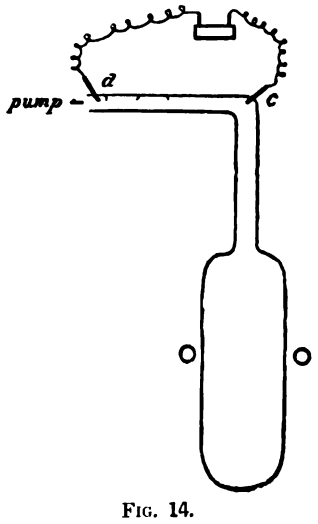

FIG. 14.

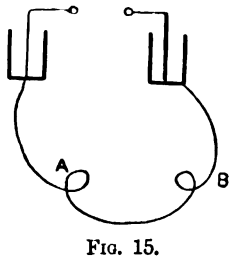

FIG. 15.

electrodeless discharge can easily be started; once having been started, it will continue after the induction coil is stopped. An experiment of this kind, which I had occasion to make, gave very clear evidence of the way in which dissociated molecules are projected in all directions from the negative electrode in an ordinary discharge-tube, but not from the positive. The discharge-tube was fused on to the pump, and at an elbow two terminals, *c* and *d*, Fig. 14, were fused into the glass; these terminals were connected with an induction coil, and the pressure in the tube was such that the electrodeless discharge would not start of itself. When the coil was turned on so that *c* was the negative electrode, the electrodeless discharge in the tube at once took place, but no effect at all was produced when *c* was positive and *d* negative. We may thus regard the effect produced by the presence of a conductor as due to the conductor catching the tubes of electrostatic induction, and concentrating them on the discharge-tubes. These tubes in many cases acting indirectly by producing a glow-discharge through the tube, which, by diminishing the electric strength of the gas, makes discharges of any other kind very much easier. Though the presence of a conductor near the discharge-tube will, in general, concentrate the tubes of electrostatic induction on the discharge-tube more than would otherwise be the case, yet this does not always happen. When in some positions the conductor may hold back for a time from the discharge-tube tubes of electrostatic induction which would otherwise pass through it, and thus diminish the maximum density of the tubes of electrostatic induction in the discharge-tube, and hence tend to stop the discharge. I have frequently met with cases where the presence of a conductor diminishes the intensity of the discharge. One of the most striking of these is when the two jars are insulated, and a square discharge-tube used. The spark was adjusted so that the discharge just, but only just, went round the tube. A sphere connected to earth was then moved round the discharge-tube; in some positions it increased the brilliancy of the discharge, and the tube became quite bright, while in other positions it stopped the discharge altogether.

The observation of the behaviour of the discharges through these tubes is a very convenient method of studying the effect of conductors in deflecting the flow of the tubes of electrostatic induction which fall upon them; for the appearance of the discharge is affected not merely by the average, but also by the maximum value of the electromotive intensity which produces it. Thus a high maximum value, lasting only for a short time, might produce a discharge, while a more equable distribution of electromotive intensity having the same average value might leave the tube quite dark.

I have employed these discharges to study the behaviour of bodies under the action of very rapid electrical oscillations in the following way. In the primary circuit connecting the outside coatings of the jar, two loops A and B (Fig. 15) were made, in one of which, A, an exhausted bulb was placed, the spark-length and the pressure of the gas on it being adjusted until the discharge was sensitive, *i.e.*, until a small alteration in the electromotive intensity acting on the bulb produced a considerable effect upon the appearance presented by the discharge. The substance whose behaviour under rapid electrical vibrations was to be examined was placed in the loop B. The results got at first were very perplexing, and at first sight contradictory, and it was some time before I could see their explanation. The following are some of these results. When a highly exhausted bulb was placed in B a brilliant discharge passed through it, while the discharge in A stopped. A bulb of the same size, filled with a dilute solution of electrolyte, produced no appreciable effect; when filled with a strong solution it dimmed the discharge in A, but not to the same extent as the exhausted bulb. A piece of brass rod or tube increased the brightness of the discharge in A; on the other hand, a similar piece of iron rod or tube stopped the discharge in A at once. The most decided effect, however, was produced by a small crucible made of plumbago and clay; this when put in the loop B stopped the discharge in A completely. I found, however, that by considering the work spent on the substance placed in B, the preceding results could be explained. When a large amount of work is spent in B, the discharge in A will be dimmed, while no appreciable effect will be produced on A when the work spent in B is small. Now let us consider the work done in a secondary circuit whose resistance is R, whose coefficient of self-induction is L, and which has a coefficient of mutual induction M with the primary circuit. If the frequency of the current circulating in the primary is p, we can easily prove that the rate of absorption of work by the secondary is proportional to

$$\frac{R M^2 p^2}{L^2 p^2 + R^2}.$$

Thus the work given to the secondary vanishes when R = 0 and when R = infinity, and has a maximum value when $R = Lp$. Thus the condition that the secondary should absorb a considerable amount of work is that the resistance should not differ much from a value depending on the shape of the circuit and the frequency of the current in the primary. No appreciable amount of work is consumed when the resistance is very much greater or very much less than this value. I tested this result by placing inside B a coil of copper wire. When the ends were free, so that no current could pass through it, it produced no effect upon the bulb in A; when the ends were joined so that there was only a very small resistance in the circuit, the effect was, if anything, to increase the brightness of the discharge in A. When, however, the ends were connected through a carbon resistance which could be adjusted at will, the discharge in A became very distinctly duller when there was a very considerable resistance in the circuit. This experiment confirms the conclusion that to absorb energy the resistance must lie within certain limits, and be neither too large nor too small.

We can now see the cause of the differences observed when the substances mentioned above were put into B. The brass rod and tube did not dim the discharge in A, because their resistance was too low; the weak solution of electrolyte, because the resistance was too great; while the resistances of the crucible and the strong solution of electrolyte which obliterated the discharge from A were near the value for which the absorption of energy by the system was a maximum.

The case of iron is very interesting because it shows that even under these very rapidly alternating forces, iron still retains its magnetic properties. A striking illustration of the difference between iron and other metals is shown when we take an iron rod and place it in B, the discharge in A immediately stops; if we now slip a brass tube over the iron rod the discharge in A is at once restored. If, on the other hand, we use a brass rod and an iron tube, when the rod is put in B without the tube the discharge in A is bright; if we slip the iron tube over the rod, the discharge stops.

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To compare the amount of heat produced in the brass and iron secondaries, Prof. Thomson considers mathematically the case of an infinite cylinder exposed to an external magnetic force; and he arrives at the conclusion that for iron and copper cylinders of the same dimensions the waste in heat is about 70 times as much in iron as in copper, assuming that the iron retains its magnetic properties under these very rapidly alternating forces. The result explains the effect of the iron in stopping the discharge. As I am not aware that any magnetic properties of iron under such rapidly alternating forces have been observed, I was anxious to make quite sure that the difference between iron and brass was not due solely to the differences between their specific resistances. The first experiment I tried with this object was to cover the iron rod with thin sheet platinum, such as is used for Grove cells. As the resistance of platinum is not very different from that of iron, if the effect depended merely upon the resistance, slipping a thin tube of platinum over the iron ought to make very little difference. I found, however, that when the platinum was placed over the iron, all the peculiar effects produced by the latter were absent, thus showing that the effect is not due to the resistance of the iron. It then occurred to me that I might test the same thing in another way by magnetising the iron to saturation, for in this state μ is nearly unity; thus if the result depended mainly on the magnetic properties of the iron it ought to diminish when the latter is strongly magnetised. I accordingly tried an experiment in which the iron in the coil B was placed between the poles of a powerful electromagnet. When the magnet was "off" the iron almost stopped the discharge in A; when it was "on" the discharge became brighter, not indeed so bright as if the iron were away altogether, but still unmistakably brighter than when it was unmagnetised. This experiment, I think, proves that iron retains its magnetic properties when exposed to these rapidly alternating forces.

Another result worthy of remark is that though a brass rod or tube inserted in B does not stop the discharge in A, yet if a piece of glass tubing of the same dimensions is coated with Dutch metal, or if it has a thin film of silver deposited upon it, it will stop the discharge very decidedly. We are thus led to the somewhat unexpected result that a thin layer of metal when exposed to these very rapid electrical vibrations may absorb more heat than a thick one. I find, on calculating the heating effect in slabs of various thicknesses, that there is a thickness for which the heat absorbed is a maximum.

The slight increase in the brightness of the discharge in A when a brass rod is placed in B is due, I think, to the diminution in the self-induction in the primary circuit produced by this rod, whose conductivity is so good that it absorbs practically no heat.

Another point which is brought out by these experiments is the great conductivity of rarefied gases when no electrodes are used as compared with that of electrolytes. An exhausted bulb will produce as much effect on the discharge in A as the same bulb filled with a solution of an electrolyte containing about a hundred thousand times as many molecules of electrolyte. The molecular conductivity of rarefied gases when the electromotive intensity is very great and when no electrodes are used must be thus enormously greater than that of electrolytes.

Bulbs filled with rarefied gas used in the way I have described serve as galvanometers, by which we can estimate roughly the relative intensity of the currents flowing through the primary coils which encircle them. Used for this purpose, I have found them very useful in some experiments on which I am at present engaged on the distribution of very rapidly alternating currents among a network of conductors.

I have much pleasure, in conclusion, in thanking my assistant, Mr. E. Everett, who has done the whole of the very large amount of glass-blowing required for these experiments, and has rendered very efficient help in other parts of the work. My thanks are also due to Mr. A. T. Bartlett, B.A., for the assistance he has given on several occasions.

DESCRIPTION OF THE STANDARD VOLT AND AMPERE-METER USED AT THE FERRY WORKS, THAMES DITTON.*

BY CAPTAIN H. R. SANKEY AND F. V. ANDERSEN.

(Continued from page 70.)

4. Measuring Volts.

The apparatus for this purpose is shown on Fig. 1 (with connections in black) in a diagrammatic form. It consists of a D'Arsonval galvanometer, G_2, with a resistance, R_V, in series, and a rheostat, P, connected with the difference of potential leads—for instance, with the terminals of a dynamo.

The scale of the galvanometer has a second graduation constructed in accordance with a calibration, so as to have its divisions proportional to the corresponding currents through the galvanometer. This proportional scale is divided from 0 to 175 volts, and unit deflection on the volt scale is produced by a current through the galvanometer of 1 micro-ampere.

In measuring potential differences smaller than 1 volt, the rheostat P is not used, but the potential difference to be measured is directly connected into the circuit of G_2.

When measuring potential differences higher than 1 volt, the potential difference to be measured is connected across the rheostat P, of which a small section—"a" on Fig. 1—is connected with the circuit of G_2. This section "a" is so adjusted as to be exactly a hundredth part of the total resistance of P + the dynamo leads, which sum is = 250 ohms.

The ratio $\frac{a}{P + \text{leads}}$ is called the potentiometer factor.

When it is required to measure high voltages, a second and even a third rheostat, P_1 and P_2, each of 250 ohms, can be joined in series with P, and the potentiometer factor altering from a hundredth to two hundredth or three hundredth. Further alterations can, of course, be made in the voltmeter constant by varying the resistance R, as in the case of the ammeter.

The potentiometer factor is evidently independent of the temperature of the rheostat P. The temperature correction required in R_V is simply ·023 per cent. of R_V* + ·388 per cent. of G per degree Centigrade of variation. It will be seen that for the ordinary ranges the resistance of the galvanometer—about 435 ohms—is very small compared with R_V, and that, therefore, the errors in the measurements due to unavoidable small errors in the estimation of the temperature of R_V are quite insignificant. If

k = current through G per unit deflection on volt scale;
K = volts to be measured ,, ,, ,,
f = potentiometer factor;
G = resistance of galvanometer;
R_V = ,, in series with galvanometer;

then, for any deflection, D, on the volt scale,

$$(G + R)\, k\, D = f\, K\, D;$$
$$\therefore R = f_1 k K - G \quad . \quad . \quad . \quad . \quad (3)$$

In the present case,

k = 1 micro-ampere = 1×10^{-6} amperes;
G = 435 ohms (legal) at standard temperature;

therefore the resistance R to be used in series with the galvanometer to obtain different voltmeter constants = $f\, K \times 10^6 - 435$.

Table II. contains in column 1, the constants used with the instrument; in column 2, the corresponding values of R_V; and in 3, the value of the temperature correction in ohms, per degree Centigrade deviation from the standard temperature—17° C.

Table II.

Voltmeter constant, K.	R_V in legal ohms.	Correction per ° C. from 17° C.	Remarks.
0·0005	60	1·68	Direct connection.
0·001	555	1·80	
0·005	4,517	2·71	
0·01	9,469	3·85	
0·05	60	1·68	1 potentiometer rheostat
0·1	555	1·80	
0·5	4,517	2·71	
1	9,469	3·85	
2	,,	,,	2 ditto in series.
3	,,	,,	3 ,, ,,
4	12,773	4·61	3 ,, ,,

NOTE.—The resistance R_V by formula 3 is of course in true ohms; the amounts of R_V in Table II. are given in legal ohms, as the resistance boxes available were adjusted in legal ohms. For the purpose of reduction, 1 legal ohm has been taken = ·9977 ohm. The figures have further been reduced about 1·2 per cent. to balance a change of constant.

The strongest current which at any time will pass through the galvanometer circuit is the current which deflects to the end of the scale, or ·000175 ampere. The heating caused by this current in the galvanometer, as well as in the resistance-box, coils is quite inappreciable, and the galvanometer may therefore be left "on" for any length of time.

For everyday work the scale is used, the readings being well within 3 per cent. of error. For more accurate work, however, readings are taken at intervals, and the mean reading is afterwards calibrated against the standard cell as follows:—The determination of the potential difference corresponding to the given mean deflection being made by substituting for it an E.M.F. equal to that of the standard cell, shunting the galvanometer, and adjusting the resistance in series with it till the deflection is produced.

* Paper read before the Institution of Electrical Engineers.

* The coils being made of platinoid wire.

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Then, if

E = the potential difference required ;
r = total resistance of potentiometer rheostat plus dynamo leads ;
$r\,a$ = section of this resistance tapped to galvanometer ;
$R_V + G$ = resistance of galvanometer circuit when G is used as voltmeter ;
$R_1 + G$ = resistance of galvanometer circuit when standard cell is used ;
m = multiplying power of shunt when standard cell is used ;
e = E.M.F. of standard cell at the given temperature ;

we have,
$$E = \frac{r}{r\,a}\,\frac{R_V + G}{m\,R_1 + G}\,e. \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

5. Measuring Resistances.

With the addition of a few Leclanché cells, with key, and a short-circuit key for galvanometer, the apparatus contains everything required for making Wheatstone bridge tests with good accuracy.

Very small resistances, such as the resistance of a dynamo armature or of a brush contact, are, however, taken by passing a current through the resistance, reading simultaneously the amperes passing through it and the potential difference at its ends. The numerous constants given for the ammeter and voltmeter on Tables I. and II. enable the tester to get accurate measurements on this plan with current differing in strength according to circumstances. The following is an example of a test of the resistance of an armature with two different currents :—

Amperes through armature.	Volts between brushes.	Resistance. in ohms
25·9	·203	·00784
47·1	·370	·00786

Insulation resistance can be measured in the ordinary way—by the deflections—by means of the E.M.F. of any available dynamo ; and as the value of the current through the galvanometer is read direct, the time usually spent in determining the constant of the galvanometer is saved.

Example :

The E.M.F. of a dynamo running excited without load was measured on the voltmeter galvanometer G_2, in the ordinary way, and found = 103 volts. The circuit from this dynamo was then opened, and again closed by joining one end of it to the shaft, the other end to the commutator of an armature the insulation of which was to be tested. The insulating material of the dynamo armature thus formed part of the circuit, which was made direct through G_2—the potentiometer rheostat having been disconnected. The reading on the volt scale was now 89·5 ; *i.e.*, a current of 89·5 micro-amperes was passing through the circuit.

The total resistance of the circuit was, therefore,

$$\frac{103 \times 10^6}{89{\cdot}5}\,\omega = 1{\cdot}151 \text{ megohms},$$

including the insulation resistance + a few hundred ohms resistance of G_2 and leads.

The experiment was made in the manner described because there did not happen to be at the moment two sets of leads available, so one galvanometer (G_2) had to be used. Otherwise the best way is to measure the volts by G_2 and the current by G_1.

6. Description and Calibration of Instruments.

Galvanometers.—As has been already mentioned, these are of the D'Arsonval type, which was chosen on account of its dead-beatness, and more particularly its independence of variations in the surrounding magnetic field. It is hardly too much to say that a system such as that described in this Paper depends on the D'Arsonval galvanometer for its existence. The galvanometers are mounted on a stone supported on thick india-rubber rings, an arrangement which has been found to a large extent to stop the transmission of vibrations. The scales are at a distance of 5ft. from the galvanometers.

(To be continued.)

THE CRYSTAL PALACE ELECTRICAL EXHIBITION.

A meeting of the Honorary Council of Advice in connection with this Exhibition was held at the Mansion House on Wednesday, under the presidency of the Lord Mayor, to receive a report from the Directors of the Crystal Palace Company as to the progress of the Exhibition, and to consider the best method of making the Exhibition of scientific value.

The LORD MAYOR opened the proceedings by calling upon Mr. G. T. Rait to address the meeting.

Mr. RAIT stated that, in the absence of the Hon. D. G. Monson, the Chairman of the Crystal Palace Company, he had to thank the Lord Mayor for presiding, and for giving them the opportunity of meeting at the Mansion House. He had also to say, on behalf of his Company, how much indebted they were to the Electrical Section of the London Chamber of Commerce, and also to the Honorary Council, for attending that meeting. He then asked Mr. Gardner, the secretary of the Crystal Palace Company, to read the report of the Directors to the Honorary Council and Committee.

Mr. GARDNER read the report, in the course of which the Directors stated that the Crystal Palace, having been intimately associated with the early introduction in this country of what may be called the modern application of electricity, they deemed the time ripe for a second Exhibition. During the past ten years enormous strides had been made in electrical engineering ; but probably the great majority of the British public were still unaware of the vast extensions and present developments of this important branch of science. The machinery of the former Exhibition was comparatively small and inefficient. The forthcoming Exhibition would afford a favourable opportunity for conducting test experiments ; and it was believed that tests undertaken at the present time by a public body would be of great service both to the scientific world and to the industry at large. The Exhibition of 1881 was recognised as the pioneer of electrical engineering in this country, and the Directors confidently believe that the Exhibition of 1892 will be equally memorable. The forthcoming Exhibition, which would be opened on January 1, 1892, would be divided into three great divisions, each of which would be subdivided into sections. First division, heavy electrical engineering (electric lighting) : second division, utilisation of electric currents other than for lighting ; third division, generation and utilisation of electric current from primary batteries, in connection with telephony, telegraphy, and other purposes. The space available for the above purposes, though large, has, the Directors state, been over applied for, and every section of the industry will be well represented. Invitations are to be issued to public bodies throughout the United Kingdom to visit the Exhibition.

The LORD MAYOR stated that the report which they had just heard read was extremely interesting. They had his best wishes, as representing the City of London, that it would be a success, and anything that he could do towards that end would be most readily done.

Mr. W. H. PREECE stated that there was no doubt that during the past ten years very great progress had been made, both scientifically and practically, in applying electricity not only to the purposes of lighting, but also to the utilisation of waste, and to the development of heat in places where the mode of producing heat now was most objectionable. Most of these matters, as well as many others too numerous to mention, would be dealt with at the forthcoming Exhibition. The practical application of electricity to the wants and purposes of mankind seemed to be only limited by the inventive genius of those who were engaged in studying this wonderful science. The demand, too, for the application of electricity seemed to be almost unlimited. Such an Exhibition would take the place very much of an educational establishment ; and they would also have the means by which those who were experts could study the progress which had been made in other countries. He believed that the Exhibition at the Crystal Palace in 1881 was called "International." The word "international" had, however, very much dropped out of fashion. Such Exhibitions were becoming far more national than international. The forthcoming Exhibition at the Crystal Palace would be national, and would be a means by which English engineers would have an opportunity of making comparisons, without being affected by prohibitive tariffs. They had to show as far as they could the development of electricity. The report referred to certain tests that would be made, and he was asked to propose the appointment of a committee of experts whose duty it would be to perform the functions of juries. He concluded by proposing the appointment of the following gentlemen as a committee of experts :—Prof. W. Grylls Adams, Prof. W. E. Ayrton, Major P. Cardew, Prof. W. Crookes, Sir James N. Douglass, Mr. W. B. Esson, Prof. D. E. Hughes, Mr. Gisbert Kapp, Prof. A. B. W. Kennedy, Mr. W. H. Preece, Prof. J. Perry, and Prof. Silvanus Thompson.

The DUKE OF MARLBOROUGH, in seconding the motion, said there was no doubt that the formation of the proposed committee would help to give the Exhibition an instructive character. From his point of view as Chairman of an Electric Light Company, or from what he would call the commercial side of the question, he would not go quite so far as Mr. Preece in saying that they had arrived at the time when they could produce the same amount of effective light at the same price as gas ; but he had no doubt that the time was rapidly approaching when they would do so. Since the Exhibition at the Crystal Palace in 1881 such great progress had been made in the industry that they had now got it on to a safe commercial basis. In the City of London they were interested in one of the largest problems in connection with electric lighting. The City of London had not only given the franchise to a public company for the lighting of the houses and offices in this important centre, but had also been public-spirited enough to give the Company the street lighting. A great duty and responsibility devolved on the Company, which had undertaken this work, and he hoped the Company would be able to make its start in private installation work by having the pleasure of lighting the Mansion House. Undoubtedly a great deal of work would have to be done before the City could be properly lighted by electricity. The streets were so full of gas and water pipes and post-office cables, as well as a great many other things of the kind, that it was extremely difficult to know beforehand whether they would find room for putting the cables down which were required for the purpose. It was in view of this difficulty that it had been resolved to adopt a system of light which entailed the use of converters, which, however, would not be in the houses of the consumers, but under the charge of the generating company. To

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carry out the work properly must, however, be a matter of time. The City Commissioners of Sewers had really shown great indulgence to the new Company; but he would take that opportunity of asking the City authorities and the public to be indulgent with the enterprise, and not to press it forward too hurriedly. If time were given to them he had not the least doubt that the public would come in with capital, and that the City of London would be one of the standing instances of the early successes of electric lighting. The company which had the City lighting also had a free field—no competition—while in other cases the Board of Trade had thought it right to give the lighting to two companies—one on the continuous and the other on the alternating system. He doubted the wisdom of this course. He was glad to see that the report which had been read to them embraced so many points in the electrical industry. As Mr. Preece had said, it covered the widest field; and the fact was that there was no limit to which the application of this science was not capable.

The resolution was unanimously agreed to.

Mr. RAIT then cordially thanked the Lord Mayor for presiding. He expressed a hope that the Exhibition might be opened punctually on the 1st of January, and that the Lord Mayor might honour them on that occasion with his presence. The Crystal Palace Company would do all in its power to make the Exhibition a success in every way; and with the assistance of the able committee of experts which had been appointed, success seemed assured.

The LORD MAYOR, in reply, repeated that it had afforded him the greatest pleasure to receive them at the Mansion House. He would do all in his power to further the movement, to which he again wished every success, and he would use every effort to attend the opening of the Exhibition next January.

The proceedings then terminated.

LEGAL INTELLIGENCE.

Hampton and Sons v. London Electric Supply Corporation (Limited).

In the Court of Appeal on Wednesday, the case of Hampton and Sons v. London Electric Supply Corporation came before the Master of the Rolls, Lord Justice Lopes, and Lord Justice Kay, in the form of an appeal from the judgment entered by the Lord Chief Justice in favour of the defendants.

Mr. Jelf, Q.C., and Mr. Lee Roberts appeared for the plaintiffs in support of the appeal; while Mr. Moulton, Q.C., Mr. Pyke, and Mr. Hanhan, opposed it on behalf of the defendants.

Mr. JELF, in supporting the appeal, said this was an action brought by Messrs. Hampton and Sons, of 8, 9, and 10, Pall Mall East, S.W., against the defendants, to recover damages for an alleged breach of contract, by which the defendants agreed to supply them (plaintiffs) with the electric light. The case was tried before the Lord Chief Justice and a special jury, who found that there was a contract by the defendants to supply the plaintiff with electric current up to 600 lights on the terms embodied in the application form; that the defendants had broken the contract, and that the plaintiffs had suffered damages to the extent of £175 beyond the sum which had been paid into Court, without any admission as to liability. Notwithstanding these findings, the Lord Chief Justice entered judgment for the defendants. The learned judge appeared to have taken the view, that although the parties intended that there should be a contract for the supply of electric current, and that although the plaintiffs acted on the faith of the contract, and expended a large sum of money in preparing their premises for it; yet it was impossible to put one's finger upon anything that constituted an actual contract upon the part of the defendants to supply electric current for any time. The learned counsel submitted that there was clear evidence of a contract between the plaintiffs and the defendants. The letters contained ample evidence that the defendants accepted the plaintiffs' application. After having accepted the plaintiffs' application and allowed the plaintiffs to go to great expense in preparing their premises for the light, the defendants said they could not supply the plaintiffs' premises from their Grosvenor Station owing to the demand upon that station.

Mr. MOULTON: It was tremendously black weather.

The MASTER OF THE ROLLS: Yes. I remember something very black about the supply from the Grosvenor.

Mr. MOULTON, on behalf of the defendants, said that plaintiffs desired to be supplied with the electric light and the defendants were anxious to supply it, but there was no contract. There was clearly no contract to supply the current for any definite time, and in such a case as the present that meant there was no contract in respect of which anybody could sue.

The MASTER of the ROLLS said he agreed with the Lord Chief Justice that there was no contract for the supply of the electric current which would bind the defendants. There was no contract to supply either for a specified time or for a reasonable time; and a contract to supply for as long as the person supplying chose was equivalent to no contract at all, and no person could sue in respect of any breach of it.

Lord Justices LOPES and KAY concurred.

Appeal dismissed accordingly, with costs.

Chase v. Henley's Telegraph Works Company (Limited).

In the Queen's Bench Division on Monday, Mr. Justice Mathew and Mr. Justice Charles, sitting as a Divisional Court, had before them the case of Chase v. Henley's Telegraph Works Company, which was an appeal by the defendant Company from the decision of Mr. Justice Jeune at Chambers, refusing to set aside the judgment entered by the plaintiff.

Mr. RAM (with whom was Mr. Reid, Q.C.,) said the plaintiff originally brought two actions against the defendant Company to recover sums of money in respect of commission earned under an agreement. In the first action the plaintiff claimed £2,100, to be paid partly in cash and partly in shares of the International Cable Company; and in the second he claimed £1,117 in cash. The actions were consolidated, and subsequently an agreement was drawn up, embodying terms for settling them. Under the agreement it was arranged that the claim should be paid half in cash and half in shares of the International Cable Company. It was further provided that if the terms of the agreement were not carried out by the defendant Company, judgment should be entered for the plaintiff. On the execution of the agreement of compromise the defendant Company paid all the cash due by them; but on the 26th of July, 1890, an order was made to wind-up the International Cable Company; and the defendant Company were prevented from handing over shares in that Company in accordance with the agreement. On 17th of April, 1891, judgment was obtained by the plaintiff for £1,608. 10s., thus treating the shares in the International Cable Company which had not been transferred as cash. Mr. Justice Jeune had refused to set that judgment aside, and the defendant Company now appealed. He (the learned counsel) submitted that the plaintiff might have obtained a transfer of the shares at any time for what they would have been worth, and that, therefore, the judgment ought not to stand.

Their Lordships, without calling upon Mr. Bankes for the plaintiff, dismissed the appeal with costs.

Lane Fox v. Kensington and Knightsbridge Electric Lighting Company.

Mr. Justice Romer, in the Chancery Division, heard on Saturday last the case of Lane Fox v. Kensington and Knightsbridge Electric Lighting Company. The action is one for alleged infringement of patent. The case now came before the Court on questions as to the sufficiency of interrogatories relating to the novelty of the invention and other matters. Mr. Wallace, who appeared in support of the application, obtained in one instance a fuller reply with respect to a question of the novelty of the patent, but failed on other points. His Lordship decided that the costs shall be the costs of the other side in any event.

Nourse v. Boland.

On Friday last, in the Queen's Bench Division of the High Court of Justice, before Mr. Justice Wills, sitting without a jury, the case of Nourse v. Boland came on for hearing. Mr. Asquith, Q.C., M.P., and Mr. Gore were counsel for the plaintiff, while the defendant was represented by Mr. Bigham, Q.C., and Mr. Lewis Coward.

Mr. ASQUITH, in opening the case, said the action was brought to recover remuneration for work done by plaintiff, as he alleged, at the request of the defendant, in connection with procuring the sale of certain electrical patents from an American company, to which they originally belonged, to an English company which was ultimately floated. Both plaintiff and defendant were American gentlemen; Mr. Nourse, who had independent means, having been resident in this country for some years; defendant only came over to England from time to time in connection with this matter. There was a company in Boston called the Thomson-Houston Electric Welding Company, and it possessed a patent for working a process under which electricity was applied to the welding of metals. In 1889 the American company despatched a Mr. Lewis and the defendant to England for the purpose of effecting a sale of their patents to a company or syndicate. The plaintiff was first put into communication with Mr. Lewis, and he took him to a firm of financiers in the City of the name of Russell and Co. In the course of conversation Messrs. Russell and Co. said they would not feel inclined to entertain the proposal of forming a company until the validity of the patents and their practicability had been submitted to a practical expert, and he suggested that Mr. Matheson should be called on to make a report. Several further interviews took place, after which Mr. Lewis went away, whereupon defendant arrived, and he continued the negotiations. In consequence of a letter from Lewis the plaintiff, on September 8, 1889, went to the Hotel Metropole and saw defendant. He arranged to take Boland to Messrs. Russell and Co. to continue the negotiations which Lewis had left incomplete. Many interviews took place, plaintiff assisting at all, and he suggested that it would be desirable, if a company was to be brought out, that some experimental works should be erected in the first instance, so that a practical test of the patents should be undertaken, and people be able to verify for themselves the value of the invention. Messrs. Russell agreed to get together £20,000 for the purpose of constructing experimental works, and if successful they agreed to form a company with a capital of £250,000, for which the patents were to be sold. After some time, however, the defendant introduced the matter to the City of London Contract Corporation, and they agreed to float a company which was to take over the patents. Although plaintiff was disappointed at the negotiations with Messrs. Russell and Co. falling through, he continued to render defendant assistance in the changed aspect of affairs. A forge was erected at Hoxton, and plaintiff went about among friends in the City, many of whom he hoped would subscribe to the capital of the Company. In fact, he devoted the greater part of the business hours of a year to the work, and in promoting the success of the undertaking. The Company was formed in August last under the name of the Electric Welding Company (Limited), with a capital of £460,000; and the question for his lordship was whether plaintiff was entitled to any remuneration for the services he undoubtedly rendered defendant, and for which he had been led to expect payment.

Mr. THORNDIKE NOURSE, the plaintiff, then went into the box, and stated that his business was to bring sellers into communication with possible buyers.

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In cross-examination the plaintiff said he had been asked to get his friends to subscribe to the capital of the Company, and he was to have 5 per cent. on the amounts so subscribed. Afterwards, however, he was told that his proceedings were likely to interfere with a Mr. O'Hagan, who was acting in the matter, and he was asked by the defendant to withdraw his efforts. If he had been allowed to carry out his work to its completion he would have been satisfied with the 5 per cent. he had been promised; but his complaint was that the business was taken out of his hands, and he was prevented from getting the money he had been expecting to earn.

Certain interrogatories and other documents having been put in, this concluded plaintiff's case.

Without addressing the Court Mr. Coward called the defendant, Mr. W. A. Boland, who, in the course of his examination, said when plaintiff called on him he offered to introduce him to Messrs. Russell and Co., but he did not accept the offer, as he did not wish to interfere with what Mr. Lewis was doing, as Lewis was coming back to London. Later on he saw Nourse again and told him he had arranged the sale of the patents, and there was nothing he could do in the way of negotiations. He added that he had dismissed Russell and Co. from the matter, as they had declined to come forward with any money.

Mr. O'HAGAN, the Chairman of the City of London Contract Corporation, and Mr. MATHESON having been called,

Mr. JUSTICE WILLS said he was of opinion the plaintiff's case had been disposed of; and gave judgment for the defendant with costs.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November* 7, 1891.

Electric Heaters.—An effort is being made just now to put divers sorts of electrical heating apparatus on the market. There are at present several very excellent forms of electric heaters for small work, and at least one of these—the Burton heater—is finding its way into a fair amount of use on electric cars. In point of economy it does not compare very favourably with coal stoves, but in comfort to the passengers and convenience it is unsurpassed. About 2 H.P. is required to heat an ordinary 16 or 18-foot car in cold weather.

Electric Lighting Effects.—One of the prettiest applications of electric lighting that New York has witnessed for many a month was to be seen last Monday evening at the Madison-square garden. A very beautiful flower show is now in progress there, and the interior of the building is illuminated not by the regular incandescent lamps ranged along the roof, but by festoons of Chinese lanterns strung in every direction radially and across the building. These are many hundreds in number, and each contains an incandescent lamp, except where the festoons cross, and at these points a gigantic Chinese lantern holds an arc lamp. But the finest effect, perhaps, was seen outside. The tower of the building had just been completed, and the weather vane—a colossal statue of Diana—had just been placed in position. The statue stands on a gigantic crescent, which blazed with 200 incandescent lamps. Two huge search lights were turned on the statue and on the upper portion of the tower, bringing it out into bold relief against the almost black sky, while immediately under the crescent from time to time a similar light was turned on at full force. In addition, the tower itself was brilliantly illuminated with electric lamps. The next evening the search light on the tower of the garden was used to signal, by prearranged code, the result of the New York State election to the cities immediately surrounding New York.

High-Pressure Electric Transmission.—Rapid transit seems to be making particularly little progress. The plans presented, as I have stated before, are rather too elaborate to invite capital, and very little is now heard of any definite efforts to hasten the work. Electrical rapid transit is likely to come in Chicago long before New York; indeed, it will not be surprising if the World's Columbian Exposition saw some very striking examples of it. It is somewhat doubtful if the plan which has more than once been suggested of transmitting power from Niagara will be carried out, as the chief of the Electrical Department does not at the present time see where the funds for such an experiment are to come from. But America is likely soon to have one or more good examples of the use of very high voltages in power transmission. At least, plant of this description is likely to be erected in California before long. Success may be safely counted upon, for the climatic conditions in that State are far more favourable than those under which the Lauffen-Frankfort transmission was carried out.

NEW YORK, *November* 18, 1891.

The Microphone "Interference" Case.— It has been rumoured within the past few days that a decision in one of the Bell Telephone Company's interference cases had resulted in the issue of a patent which would practically give that greedy corporation a monopoly of the business for a good many years to come through the medium of a broad claim on the carbon transmitter. The Bell Telephone Company, more than any other organisation in the history of the United States Patent Office, has abused the privileges offered by Patent Office procedure, keeping interferences alive and patents withheld, purely and simply for the purpose of obtaining—contrary to the spirit of the patent laws and public policy—patents so dated as to prolong its atrociously abused monopoly. The rumour seems at present writing to be groundless, probably being merely an attempt to influence the price of telephone stock; but there is great danger that such a patent may be obtained by the Telephone Company, unless so strong a pressure of public opinion is brought to bear upon the Commissioner of Patents as to check any action on the ground of fraudulent intent on the part of the litigants, a conclusion that might well be made, considering that the Bell Telephone Company has for years owned both sides of all the important telephone interferences.

The Overhead Wire Question in New York.—The perennial war on the overhead electric wires in New York is threatening again, and indeed the Board of Electrical Control has recently taken steps to have a considerable number of overhead wires taken down and put into the conduits. Meanwhile the subway facilities are as bad as ever, and the old wrangle between the Subway Company and the Electric Light Companies is as yet undecided.

Storage Battery Traction.—The recent report of the Commission appointed by the United States Government to look into the construction of subways in Washington will probably have the effect of bringing further pressure to bear against overhead wires in this country. The trolly system of electric railways is thoroughly prevented from making any extensions in Washington by the strong sentiment against overhead conductors; and the result has been the establishment of an experimental line of storage cars, under the superintendence of Mr. C. A. Mailloux, which is reported to be doing very fair work. Speaking of storage batteries, the Waddell-Entz car, equipped with alkaline zincate batteries, has been recently making a series of very successful experimental runs. A large number of the cells have now been manufactured, and tests seem to show that they are capable of doing very excellent work. The question of durability, of course, is a difficult one to decide, as the type has not been manufactured long enough to permit of very accurate judgment. The inventors, however, say that the results thus far obtained have been very encouraging, and appear to show that in spite of the low voltage of the cells they are admirably adapted for street car service.

Forthcoming Edison Alternate-Current System.—The Edison Company is reported to be getting ready to put its alternating system on the market. It will be remembered that something over a year ago a suit was brought by Ganz and Co. against the Edison Company on the ground that the patents which the latter had undertaken to work in the United States had been simply quashed, and that nothing has been done towards developing them. If rumour speaks correctly, the first of next year will see the Edison Company exploiting an alternating-current system; and it is expected that this will possess the peculiarity of utilising the three-wire system and 110-volts, somewhat perhaps after the manner suggested by H. Ward Leonard in his Paper read before the National Electric Light Association at Montreal. Details of the Edison apparatus are not at hand. It is understood to be not widely different in general character from the systems usually employed in this country; and as it has been worked out largely by Mr. A. E. Kennelly it is only fair to assume that it will prove successful.

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CORRESPONDENCE.

THE THEORY OF THE WIMSHURST MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having read with considerable interest a letter on the above subject by M. G. Pellissier in your last issue, and also an article proposing a new theory by the same author in your issue of October 2nd, I should like in the first place to say a few words in reply to his criticisms on the theory of the Wimshurst machine, which I give in my book on Influence Machines; and, in the second place, to offer a few criticisms on the theory which M. Pellissier proposes.

M. Pellissier says in his letter that the theory which I have given is "no other than that of Prof. Thompson." A more careful comparison will show that this conclusion is erroneous. Prof. Thompson's latest theory of the Wimshurst machine, as far as I know, is given in his Paper on the Influence Machine read before the Institution of Electrical Engineers (*The Electrician*, Vol. XXI., June 8, 15, and 22; *Journal* of the Inst. Elec. Eng., Vol. XVII., p. 613). The assumption with which he starts is that "some of the metal carriers are charged positively, others negatively." It is not stated whether the positive and negative carriers follow each other in any particular order; but farther on we find that it is assumed that the carrier on the back plate, which at any instant lies opposite the upper end of the neutralising rod of the front plate, has always a positive charge. Such a state of things would, of course, soon impart to the plates of the machine the *final* distribution of electricity which is known to exist when the machine is active; but it appears to be an explanation of how the Wimshurst machine is excited by the influence of a foreign electrified body held opposite one of the brushes, rather than a theory of how the machine excites *itself* with the plates in any condition (electrically) at starting.

In my theory, I start with the assumption that one-half of one of the discs has a small positive charge, and the other half a small negative charge, and from this I show that by the action of the machine a similar distribution at right angles will be produced on the second plate. Then, owing to the fact that the inductive action of all the similarly charged carriers on one plate is focussed on the touched carrier on the other plate, a greater charge is produced on the touched carrier than on any one of the inducing carriers. This increase of charge follows the same law as the increase of money at compound interest. A charge of electricity invested, as it were, in a carrier of the inducing plate, produces (with the help of the other adjacent carriers) in the touched plate a charge equal to the original charge invested, plus more or less interest, according as there are more or less sectors on the machine and according to the distance between the plates, &c. The increased charge on the second carrier now becomes the principal for producing a further increased charge on the first plate, and so on, according to the well-known formula for compound interest.

This law of the increase of the charges I have explained in the theory given in my book, though not in much detail, as it had already been explained with reference to previous machines. M. Pellissier also makes this very clear in his article (*The Electrician*, Vol. XXVII., October 2nd, p. 604). Prof. Thompson does not mention this law of increase in his Paper already referred to; in fact, one would think that he had overlooked it in his theory of the Wimshurst machine, as he assumes in his illustration that six positive units in an inducing carrier will produce six negative units in a touched carrier, conditions under which it is easy to see that there would be no increase of the charges on the carriers.

My theory was not intended to show how the *final* distribution arises from the *primitive* distribution, for the reason that I considered that to be impossible in the present state of our experimental knowledge, and by no means simple even with sufficient experimental data. All that I intended to explain was that the *final* distribution was stable and tended under proper conditions to increase indefinitely in intensity,

Nor do I think that M. Pellissier in his article in the *Journal de Physique* of which you publish the translation in your issue of October 2nd last, has succeeded in establishing the nature of the primitive distribution, or demonstrated the nature of the process by which the *primitive* distribution passes by the action of the machine into the *final* distribution. M. Pellissier assumes that one of sectors A (*see* Figure, *The Electrician*, Vol. XXVII., October 2nd, p. 604) of the back plate opposite the upper end of the neutralising rod of the front plate has a small positive charge. No explanation is given in his Paper why this particular sector should have a positive charge. But assuming that this *primitive* charge exists he claims to show that the *final* distribution will result by the action of the machine. Now the new element which M. Pellissier claims to have introduced into his theory of the Wimshurst machine is the inductive action of a charged sector upon adjacent sectors on the *same* plate. It has not been usual to take this into account, and, in fact, in most machines it would be much less than the inductive action of the charged sectors on the *other* plate. But the mistake made by M. Pellissier is in assuming that this side action on adjacent sectors only acts towards one side only, that is on the side where it helps the final distribution; its action towards the other side, namely on the sector A_7, will produce a negative charge where a positive charge is required and retard the *final* distribution. Indeed, to follow with rigid accuracy the development of the charges by the machine from any given primitive distribution of charges, we must calculate the effect on each sector when in contact with a brush by taking into consideration the amount of charge, distance, &c., of every other carrier on both plates. Is this possible, or is it worth the labour?

I fear that I have written you at much too great a length on a subject which is at present merely of theoretical interest; but the influence machine may any day become of the greatest practical interest, when electricians will discover that it is now, as regards efficiency, in about the same condition as the dynamo was when Wheatstone and Siemens read their historical Papers before the Royal Society.—I am, &c.,

November 23, 1891. J. GRAY.

ELECTRIC LIGHT CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with interest your leading article under the above heading, which appeared in your issue of the 20th inst., and ask your permission to make some remarks thereon in the columns of your journal. I will notice first the remark you make concerning the insulation resistance of cables below 150 megohms, which, you say, makers, in their lists, "discreetly pass by in silence." The reason of their doing this is that such cables are insulated with lappings of pure indiarubber, and no test *under water* can be guaranteed for cables insulated only with pure indiarubber tape. Those cables having the insulation resistance stated are tested under water after at least 24 hours' immersion. The tests are usually taken with a mirror galvanometer, and the voltage seldom less than 400, and, of course, often very much higher. This minimum test of 400 volts is necessary to ascertain whether the cable is perfectly manufactured or not. Those who have had experience in cable factories are aware that for a given thickness of insulation the megohm test is a true indication of the quality of the material, and the workmanship. The buyer satisfies himself of the thickness of the insulation by the inspection of samples. We are aware that price lists sometimes give the diameter of the cables; but the buyer who knows his business does not take this as giving an indication of the thickness of the insulating material, as the cable can be made large by tapes or thick braiding yarns, which, of course, are considerably less expensive than the insulating material proper.

The course adopted by my Company in preparing its price lists may be of interest to you. In the first instance the thickness of the insulating material is decided upon, sufficient being given to ensure what we consider necessary for mechanical protection; then the degrees of quality of material we apply fixes the insulation resistance in megohms. For example, we consider that a 7/15 cable for house-wiring should have an insulation ·057in. thick, making the diameter *outside the insulation* ·330in. We then use this size for our three classes usually

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employed for house-wiring. The diameters of the cable are thus the same, but the insulation resistance varies according to the quality of the rubber used; class "N," at £90 per mile, giving 300 megohms per mile; class "G," at £95, giving 750 megohms per mile; and class "A," at £102, giving 2,000 megohms per mile. The small increase in the price, compared with the increase in the insulation resistance, is partly accounted for by the fact that the specific gravity of the best quality vulcanising rubber is less than that of inferior qualities, and therefore a less weight of the former than of the latter is required for a given diameter. The experienced cable manufacturer knows exactly the minimum insulation resistance his various qualities of vulcanising rubber will give, as raw Para indiarubber, unlike gutta-percha and many other insulating materials, does not vary, the raw Para of to-day is the same as that imported years ago.

It is perhaps to be regretted that I cannot write of this matter without there being a suspicion of advertising the wares of my Company, but I feel that a letter dealing with a subject of such importance is more worthy of attention when written over the signature of the writer.—I am, &c.,

G. Sutton,
Manager W. T. Henley's Telegraph Works Co., Limited.

27, Martin's-lane, Cannon-street, E.C.,
November 25, 1891.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

Now Ready.—"The Electrician" Primers (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

Tenders Invited.—The London County Council invites tenders for the electric lighting of the central offices of the Council in Spring-gardens. Tenders must be sent in by 10 a.m. on December 15th. Further particulars appear in our advertisement columns.

——— The trustees of the town and harbour of Whitehaven invite offers from companies or persons for the transfer of their statutory powers under the Whitehaven Electric Lighting Order, 1891. Tenders must reach Mr. John Collins, the secretary to the Trust, Town Hall, Whitehaven, not later than 12 noon on December 12th.

The Chicago Exhibition, 1893.—It is announced that the Royal Commission for this Exhibition are now prepared to receive applications for space in the British Section. Applications are to be made upon forms which may be obtained at the offices of the Society of Arts, London, where all further information can be obtained.

Mr. C. Polyblank.—This gentleman informs us that he has resigned his position as mechanical and electrical engineer to the Swansea Harbour Trust, and has opened an office at 47, Wind-street, Swansea.

A Staple Driver.—In a Trade Note on p. 727 of Vol. XXVII., we ventured to offer some criticisms on the staple-driver which was there described. So far from being offended, as sometimes happens when manufacturers expect nothing but praise or a bald description of their goods, Messrs. Woodhouse and Rawson United (Limited) have modified the tool in accordance with our suggestions, and have sent us a sample of the improved form. We have given it a trial on several yards of bell wire, and find that it works very well. The plunger is hollowed out at the end, so that the staple cannot be driven too far.

Mr. W. S. Sargeant.—This gentleman, who is the late manager of the electric and steam launch works, Strand-on-the-Green, Chiswick, has severed his connection, by mutual arrangement, with Messrs. Woodhouse and Rawson United (Limited). He is now carrying on business as an electric and steam launch builder, and laying down plant and machinery for the construction of electric motors for water propulsion and compound surface condensing engines at Strand-on-the-Green, Chiswick.

The Electric Light in British Guiana.—A correspondent writes us that considerable progress is being made in the electric lighting of British Guiana, and that at present the Company lighting Georgetown have a Thomson-Houston A 35 650-light alternator and a Thomson-Houston E 12 arc machine for nine 1,200 c.p. lights. About 500 16 c.p. lamps are installed, and also a circuit of forty 25 c.p. series lamps for street lighting. The machines are driven by a Macintosh-Seymour engine of 100 H.P. The Company have a contract with the Town Council of Georgetown to commence on January 1st next with 190 series street incandescence lamps of 25 c.p. each, and 18 arcs of 1,200 c.p.; and for this purpose a Thomson-Houston A 35 and a Thomson-Houston K 12 arc machine are being put down. The last-mentioned installation will be driven by another Macintosh-Seymour engine of 130 H.P., and the first Babcock Wilcox boiler ever introduced into British Guiana is now being put down.

Electric Light Cables and Wires.—We have received the new price-list of Henley's Telegraph Works Company, giving the usual particulars of their well-known cables. Conductivity of 100 per cent. of "pure copper" is offered. The list is dated October, 1891.

——— The Fowler-Waring Cables Company send us a price-list of their manufactures. It bears no number or date other than 1891. The accumulation of price-lists in most offices is so great that it is very important that the latest list should be easily recognised. A brief description of the method and materials employed in the manufacture of these cables is given. Directions are given for jointing and insulating lead-covered cables, but they assume a good deal of previous knowledge on the part of the reader. It is necessary to seal up the ends of these cables to prevent access of moisture to the insulation. Two methods are described: one is merely a cap of Chatterton; the other consists in cutting away an inch and a-half of lead, and thoroughly insulating the part bared to a level with the lead, and wrapping over all stout waterproof tape. The end piece of lead is then well insulated from the rest, and may be soldered to the copper conductor, completely protecting the insulation from the action of wet.

——— The weights and resistances of the stranded conductors of the Fowler-Waring list appear to be taken from actual observation. The sectional area of a mile of 7/16 is about three per cent. greater than seven times the area of a mile of No. 16. The weight is a little over two per cent. greater. The resistance is greater than one-seventh that of a single wire, but is less than the inverse ratio of the weights, as might be expected (*The Electrician*, Vol. XXVI., p. 412). It is not clear how the Henley Company manage to give such a liberal weight of copper; their 7/16 is five per cent. heavier than the single wire, and the resistance only differs by one per cent. from the inverse ratio of the weight. The extra weight may be due to a shorter lay.

Messrs. Poole and White (Limited).—This firm report that they are busy in all departments, and that a very heavy demand is made upon them for the Poole and White Holder, which has been so favourably received by the trade.

Messrs. Carrick and Ritchie.—This firm forward us illustrated particulars of the "Waverley" Turbine, and inform us that they have recently fitted up a turbine working with a fall of 650ft., the highest fall (so far as they are aware) in Great Britain. There is, no doubt, a great development taking place in the application of water power for electrical purposes, and Messrs. Carrick and Ritchie are making a number of turbines to meet this demand. Accompanying the printed particulars sent are illustrations showing the turbine fixed and at work under varying conditions.

The Mills Compound High-Pressure Sectional Steam Boiler.—We have received printed illustrated particulars from the manufacturers of these boilers, which claim to give high economy, duty, and efficiency. The feature of this boiler which distinguishes it from most water-tube boilers, is the water-cased furnace, which is practically a small Cornish or single-flue boiler within a water-tube boiler. The connections in the steam and water drums are so arranged that the nipple connection can be examined and cleaned from the outside: the inclined water tubes are expanded at each end into vertical heaters having large well areas, each containing one row of tubes. These boilers are suspended on wrought-iron girders and columns, and are free to expand and contract without undue strain. It is claimed that the boilers can be erected, completed, and tested before being enclosed within the brick-work. Tabulated particulars accompany the printed matter issued by the Company, giving the comparative tests of the boiler.

A New Tramway Brake.—The Portstewart Steam Tramway Company have had some of their tramcars fitted with the Pari Emergency Brake, to act automatically in the event of a car breaking away from the engine, and also for application by hand when required. The brake was some time ago tested by Major-General Hutchinson, R.E., and approved by the Board of Trade, the trials made to test the brake having proved satisfactory.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

October 12, 1891.

17,324. G. J. PARFITT and G. J. T. J. PARFITT. Keynsham. Improved method of electric lighting in series and apparatus therefor.

October 13, 1891.

17,399. E. T. GILLILAND. Glasgow. Improvements in dynamo-electric machines.

17,402. A. MARR. Manchester. Improvements in telephonic transmitters.

17,406. J. T. TODMAN and A. E. ANGOLD. London. Improvements in electric arc lamps.

17,426. E. ANDREOLI. London. Generating ozone by electricity.

17,430. D. M. LAMB. London. Electric batteries.

17,434. F. BRYAN AND WOODHOUSE and RAWSON UNITED (LIMITED), London. Improvements relating to dynamo-electric machines.

14,454. R. THRELFALL, London. Improvements in electric conductors for the distribution of electric currents, and in conduits therefor.

17,459. G. H. JONES, London. Improvements in and relating to electric bells and indicators.

17,470. R. J. BOTT, London. Improvements in the holders of incandescent electric lamps.

October 15, 1891.

17,581. F. J. MORGAN and W. R. JAMES. Blaina. An anti-binding wire insulator for suspending or carrying electrical wires.

17,614. A. SHIELS. Glasgow. Improvements in couplings for electric wires.

17,631. A. S. ELMORE. London. Improvements in the process and apparatus for electrolytic manufacture of tubes, pans, and other bodies of circular form.

17,652. H. H. LAKE. London. Improvements in carbons for electric arc-lamps. (The Thomson-Houston International Electric Company, United States).

17,655. G. D. BURTON, A. H. EDDY, and G. T. BRIGGS. London. Improvements relating to the heating of metals by electricity and to machines therefor.

October 16, 1891.

17,706. F. H. NALDER, H. NALDER, C. W. S. CRAWLEY, and A. SOAMES. London. An improved form of voltmeter.

17,707. F. H. NALDER, H. NALDER, C. W. S. CRAWLEY, and A. SOAMES. London. An improved form of voltmeter.

17,719. A. H. BYNG. London. An improved electric or galvanic battery, and its adaptation to brushes and other articles.

17,726. A. P. MORISON, J. HIRSHFELD, and W. WRIGHT. New York. Improvements in portable electric lamps and battery therefor.

17,731. O. LINDERS. London. Improvements in electric motors.

17,732. O. LINDERS. London. Improvements relating to electric motors.

17,733. O. LINDERS. London. Improvements in electric machines for drilling, boring, grinding, and the like.

17,734. O. LINDERS. London. Improvements in electric switches.

October 17, 1891.

17,758. THE MINING AND GENERAL ELECTRIC LAMP COMPANY (LIMITED), and J. T. NIBLETT. London. Improvements in elements for secondary batteries.

17,808. A. J. BOULT. London. Improvements in electrical accumulators or storage batteries (H. L. H. Maugras, France).

17,809. T. G. H. NICHOLSON. Liverpool. Improvements in or applicable to magnetic compasses or other instruments in which dials or movable indices are employed.

17,818. L. PYKE and E. S. HARRIS. London. Improvements in or connected with electric transformers or induction apparatus.

17,823. C. W. L. BARBER. Lowestoft. An application of the electric light to a gun for the purpose of illuminating the object aimed at.

17,831. W. J. B. BANKS. London. An improved compound for insulating, covering, moulding, and analogous purposes.

October 19, 1891.

17,836. R. N. LUCAS. London. Improvements in and relating to electric meters.

17,849. J. A. LEA, J. F. LEA and A. H. LEA. Shrewsbury. Improvements in electric light fittings.

17,852. F. J. PALMER. Dawlish. Improvements in telephone apparatus, or in telephonic instruments, and in coin-controlled mechanism for use with or in connection with same.

17,855. W. T. PRESSLAND. London. Improvements in wall plugs for electric lighting.

October 20, 1891.

17,906. J. J. APSEY. London. Improvements in electric belts and fastenings therefor, which are also applicable to corsets, bags, boots and shoes, and the like.

17,907. A. A. C. SWINTON. London. Improvements in electric signalling.

17,916. J. SHEPHERD and T. S. WATNEY. Leeds. Improvements in dynamo-

17,965. P. A. NEWTON. London. An improved mode of and apparatus for transmitting and recording electrically autographic messages, signals, and markings. (E. Gray, United States).

17,971. J. W. and C. F. DU LANEY. London. Improvements in electric clock-winders.

17,974. A. ALLEN. London. Improvements in insulation for electric conductors. (C. T. Snedekor, United States).

17,994. B. SCHEITHAUER. London. Improvements in and relating to electric batteries.

18,002. J. LA BURT and W. H. AGRICOLA. London. Improvements in railway electric block signal systems.

October 21, 1891.

18,011. A WHALLEY. Helsby. Improvements in telephone switchboards.

18,019. J. H. HINDLE. Manchester. An improved ceiling-rose or ceiling-plate for suspending electric lamps.

18,044. A. H. BROADBENT. Liverpool. Coin-freed apparatus for telephones.

18,059. F. W. GOLBY. London. Electrical counting apparatus. (G. Goulier, France).

18,080. J. H. GREENWOOD. London. Improvements in fire alarm telegraphs.

18,093. E. J. ELKINSTON. London. New or improved automatic circuit closing device for electric fire-alarms. (The Compañia Electricista contra Incendios, Spain).

October 22, 1891.

18,097. C. N. SOUTHER. London. Improvements in galvanic batteries. [Date applied for under Patents Act 1883, Sec. 103, March 23, 1891 being date of application in United States.]

18,143. H. A. MAYOR, W. A. COULSON and S. MAYOR. Glasgow. Improvements in the method of mounting storage battery plates.

18,162. H. C. GOVER. London. Improvements in electrical lamp and other fittings.

18,179. A. GRAY and R. HAMMOND. London. Improvements in or relating to the coupling of dynamo-electric machines in parallel.

SPECIFICATIONS PUBLISHED.

1890.

7,035. LEA. Electricity meters. (Price 8d.)

17,394. VIALET-CHABRAND. Making or breaking electric circuit. (Price 11d.)

17,852. BINKO. Dynamo-electric generators. (Price 6d.)

17,861. MARX. Electrical conductors. (Price 6d.)

19,033. WOODHOUSE AND RAWSON UNITED (LIMITED). (Hinde.) Electric switches. (Price 6d.)

20,100. WILLANS. Controlling supply of electric current to mains. (Price 8d.)

21,147. BOULT. (Frédureau.) Insulating electrical conductors. (Price 8d.)

1891.

10,977. DE MERITENS. Galvanic batteries. (Price 8d.)

15,575. DE MERITENS. Galvanic batteries. (Price 8d.)

COMPANIES' MEETINGS.

Swan United Electric Light Company (Limited).

The ninth ordinary general meeting of the shareholders of this Company was held on Tuesday last at the Cannon-street Hotel; Mr. J. S. Forbes presiding.

The ASSISTANT-SECRETARY (Mr. H. Charles Gover) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, I will in the ordinary course of things proceed now to make a few remarks upon the report and accounts; and probably the most convenient method will be to deal with the figures first before entering upon more general questions. The material thing in these yearly accounts is to ascertain the result of the working of the year, and that will be found in the profit and loss account, which is in fact is the trading account for that period. It is very short and very simple, and very easily comprehended. If you will kindly follow me through the debtor side, and then through the creditor side of the accounts, I think you will be able to appreciate very shortly and clearly the position of the undertaking as a going concern for the past twelve months. The first entry you see is the amount of stock on October 1, 1890, brought forward, £11,124; then comes the item "purchases," £11,723, which means the material, and, in some cases, the finished articles necessary to carry on our business. Then come the costs of the general administration of the Company—"salaries, Directors' fees, rent, office expenses, income-tax, general and law charges," £3,379. Then there are "wages and expenses at the factory," £5,107—that is over and above the mere cost of purchases and materials, being the cost of turning these into a saleable commodity. After that appears a small amount written down, £392, and "sales of ledger reserve," £300, against the probabili

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of bad debt. Then there is the "balance" of £39,038. On the opposite side of the account our business "sales, less commissions and allowances," stand at £15,348; interest and transfer fees, £1,290; dividend on shares in La Compagnie Générale des Lampes Incandescentes, less tax, £1,178; and dividends on shares in the Edison and Swan United Electric Light Company (Limited), £34,799. The stock of materials and lamps on hand with which we closed the year stands at £18,449. Well, dealing with the creditor side of the account, as representing what may be called a solid asset, and dealing with the other side as representing the cost of that asset, you see what the balance is—£39,038. You will at once observe that a very large part of that balance, representing profit, is derived from the investment of your money in the Edison and Swan United Electric Light Company (Limited), £34,799. I think I have said enough about that until I come to some details which I will deal with later on. I now take you to the balance sheet. There you see the state of the share capital. There are so many shares fully paid, and so many only partially paid—standing at £5 in the former case and £3. 10s. in the latter, and showing that the total capital is £375,071; we have an item for forfeited shares, £3,530, being the amount paid by people who failed to pay up the calls on their shares, which, after due notice was given to the parties holding them, were forfeited. Then there are sundry creditors £4,642, and the balance from previous account £8,451, because last year we did not divide up to the hilt, and carried forward that amount. This makes the sum available for dealing with £47,490. Well, in this Company as in other companies which have an annual balance-sheet and an annual distribution of profits, when they are trading on what is something like solid principles there is what is called a provisional or interim dividend. We have had it for a year or two, and on account of the first half of this year we paid £11,104 in dividend. That deducted from the £47,490, leaves £36,386 now to be dealt with to day. On the other side of the account you get a very simple statement of the position of the Company. You will see "By cost of patent rights, &c.," represented by shares in Edison and Swan United Electric Light Company, Limited, with £208,478 paid; shares in La Compagnie Générale des Lampes Incandescentes with £30,489 8s. 3d, paid; patents held by the Company for Germany, &c., as per last balance sheet, making a total of £330,837," which is the amount we have written down for the cost of all these; and if you cast your eye to the other side of the balance-sheet you will see that the capital paid up is £375,000 odd. There is, I see, an additional item of expenditure of £1,612, subject to re-adjustment between the companies, which brings the figures up to £332,449. Then comes the "outlay on factories, plant, &c., less depreciation," £1,570, because you cannot establish a factory calculated to turn out any considerable number of lamps for anything like £1,500; and that amount is low because for some years we have written off 20 per cent. out of revenue on account of the money expended in that way. "Sundry debtors" stand at £6,545, which exceeds the corresponding entry on the other side of the account, "sundry creditors," by nearly £2,000. "Stock in hand" is £18,449; "investment in Prussian Consols," £5,120; "investment in New Two and Three Quarters per Cent. Consolidated Stock," £29,004; and "cash on deposit and in hand," £26,490. Well, now, first of all, what are you going to do with the balance of £36,386? What the Directors recommend you to do they set forth in the body of the report, and that is that the dividend for the year should be at the rate of 11 per cent., which will absorb £28,376. 6s. 11d., in addition to the £11,104 distributed as interim dividend, and leave £8,010 to be carried forward for the benefit of the current year, which you will see is within £450 of the amount we brought forward the year before. This seems to be a recommendation entirely justified by the state of the balance-sheet; and I think you will agree with me that in the position of the Company it is prudent not to divide up to the hilt. Therefore, if the year's business has resulted in this, that you can pay 11 per cent. and carry forward into the current account about the same balance as you did last year, it is not so very bad, particularly when you take into consideration one of the unrealised items of the profit and loss account, and that is the stock on September 30, 1891, £18,449. I have had occasion to explain before—and, perhaps, I had better explain again, because these meetings are held only once a year, and because we know by the transfer lists our proprietors change, and some of them, at all events, are not yet familiar with the details or principles upon which this business has to be conducted—I wish to explain that it is quite certain that these lamp companies cannot conduct their business satisfactorily without having on hand a large amount of stock. The lamps, although they are generally described as being of 16 or 8 c.p. or some other denominative quality, in fact greatly vary in many particulars, and outside, what you may call the ruck of the business, there are a great many lamps made to special order, which involve a great many types and subdivisions of stock. That is a disadvantage in one sense and an advantage in another. A great business cannot be done without a large stock, which means a large amount of money locked up. That may, by and by, turn out to be an advantage to those big companies which have had the start for a term of years and have made a reputation and a *clientèle*, and which, from the fact of their being able to turn out very large numbers of lamps, can do so at a price at which a small man could not possibly live. That stock of £18,000 odd is made up very largely of lamps—in round numbers to about £11,000. Of course, if we met to day and were to say, "We have come to the end of our business," and were to realise our assets, you might ask: "What is the stock worth—how many lamps are saleable and at what price?" As you have credited the account with the actual cost you would realise a moderate profit on the sales, which is, of course, what you would do, it would be all that money to the good. Therefore, what I am dealing with now is an ascertained, humanly speaking, absolutely safe profit of 11 per cent., with £8,000 odd carried forward from the previous year, with a contingent value lying dormant, the benefit of which you will get in future years. That is the basis of the whole thing. I do not propose to go into the details of these various figures except by way of answering any questions, which I take the liberty of inviting shareholders to put to me as representing the Board. Now, I will come to something a little more general. The most satisfactory part of this report is the paragraph which tells you that the decision of the Supreme Court at Leipsic, in the patent cases which certain companies with very long names brought against this Company and their agents, has now been given in favour of the Company. This is a matter of great moment. The question in dispute was exactly the same as that which was in dispute in England when the wisdom, I think, of some of the gentlemen sitting at this table induced the Edison Company and the Swan Company to put their forces together, instead of cutting each other's throats. Oddly enough, in Germany, the Edison Company, or those representing it, and those representing the Swan Company, have not been able to follow so wise an example, with the result that they have been in litigation now for several years, the Swan Company having been brought to book by the Edison Company as infringers of its patents. We never raised that question in this country. It is not for want of trying on our part that that state of things continues in Germany. We have long tried to persuade our friends there that what has turned out to be so good in England might also turn out to be of advantage in Germany; but they have not seen it. The result is that we have now been declared in our final appeal, after protracted proceedings which are equal to anything that we know in connection with the Law Courts in England, as illustrating the law's delay, to have succeeded; that is to say, the Swan lamp has been declared to be no infringement of the Edison patents. And the result is that we are now free to go on our way without being denounced in any way as infringers, without our customers being threatened with proceedings, and without our being threatened with damages in the event of our being found guilty. And then you see that places the German business in a very different position from what it was in before; and what the Board say is, "The Directors are now engaged in the consideration of the best way to take advantage of the favourable position thus created in Germany." It is the difference between working in freedom and working in chains. Although under the German law, the penalties upon people who are wrongdoers in the dark and without knowledge are generally very light, when they have been once warned by legal notice that their policy is wrong they are pretty heavily salted. Though we went on making Swan lamps we had always the fear before us of final damages; and during the last year or two, having learned a little by litigation, and being careful lest some abstruse point might turn against us, we did not push our business as we could have done, and as we shall certainly push it now. The next paragraph is about our little investment in Paris. The same conflict is going on there as to the patents, and I suppose about the time these run out the same decision will be come to. The Company in Paris is not doing so very well, for the reason that they are in litigation with everybody that can make lamps and send them into France, and there is what is called a "cutting of rates" going on. But it is still possible that that state of things may terminate sooner or later, and I suppose the French companies will come to some understanding among themselves, because, of course, there is no particular object in men giving their brains and money to manufacture lamps and sell them at a price which leaves no profit. People may do so for a time, but they ultimately get tired of it. That brings me really to the end of the report; but I will make this observation. The Swan Company have got now into a peculiar position. We have divested ourselves of any care or trouble about the working of our British patents, and we did that by virtue of £208,478 of capital held in the Edison and Swan Company. I do not know whether honourable proprietors appreciate that that Company is doing very well, and that in all probability in the future it will be, at all events, tolerably well off. It may be like other companies; they have got to face the state of things which will arise when the protected period runs out. That they have foreseen. They have laid their plans and shaped their policy upon this: that they must make hay while the sun shines—that is to say, they must make the best lamp, get the best *clientèle*, and establish the best reputation, and at the end of that time they must take their chance with other people. But they will then find themselves in a position to make as good a lamp as anybody else, and probably better; they will find themselves in a position with a great number of persons who, having a knowledge of the article, will not be easily tempted to change it very readily for another; and with the ease of capital at their command they will be able to produce these lamps at a price as low as, if not lower, than other people can; and, therefore, will be able to sell at the minimum of profit. In fact, it means this: a small profit on a large number, instead of a large profit on a small number; and you participate in that proceeding to the extent of £208,478. You are the largest shareholders in the Edison and Swan Company. As to our lamp business in France, that is represented by £30,489. The French Company are very powerful, and the French people—we are inclined to think so—are not so methodical or business-like as we are; they are more scientific and logical, but not quite so practical; but they will be able to take care of themselves. Let us hope so. This German business, which may be a more or less important factor, in proportion to its magnitude, was exceedingly troublesome to the Directors in former years. The lawsuits are now settled, and, therefore, it is just for consideration whether it is worth while administering that portion of the business as a separate Company with separate machinery for the purpose. When the litigation was over here, we thought it would be a prudent thing to consider at all events whether the Edison and Swan Company in England might not absorb upon some fair and reasonable terms the outlying business and assets generally of the Swan Company. They have got a considerable sum of money and other things at command, which could be utilised by the Edison and Swan just as well as by the Swan Company as a separate undertaking. We shall probably desire, at some early date, to consult the proprietors on details. The Edison and Swan Company are a united body, but although they are united they consist of two parts; and although they have an identity of interest, on the question of the buying and selling of a new business they might not have. We have

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imported into our happy family of Directors members from the Edison and Swan Company, who represent themselves largely and their co-partners. We have gentlemen connected with our Board who hold largely for themselves and represent the interest of the Swan Company, and we thought it prudent that two gentlemen on either side should meet and consider this question of fusing the existing Swan Company, or, rather, taking over the assets and outstanding business not already provided for upon some terms which will be acceptable to the proprietors of both companies. It will not take very long to come to some reasonable conclusion upon it. I thought that the proprietors should know that. It will, perhaps, save somebody asking questions. We think that the time has gone by when it is necessary to carry on the Swan Company as a separate undertaking merely for the sake of conducting the German business, when it could be equally well and perhaps more profitably done by the Edison and Swan Company. I hope the principle will commend itself to the proprietors. Unless I am challenged upon any figures as to which any proprietor is in doubt, I will now move:—

"That the report and accounts for the year ended September 30, 1891, be received and adopted."

Mr. F. R. LEYLAND seconded the motion.

A SHAREHOLDER asked how long the German patent lasted.

The CHAIRMAN: The German patent is not in question. All that has been determined in Germany is that the Swan patent is not an infringement of the Edison. We have never got so far as to establish the Swan as a patent, and I don't suppose we ever shall.

The motion was carried unanimously.

The CHAIRMAN, continuing, said: There is one thing which I have found in my experience: it is much easier to put and carry than most things—that is, the distribution of a dividend. The dividend that we are to propose is so complex that it bothers me. The cause of that complexity is, however, very simple when you do understand it, like that egg of Columbus. The shares are divided into £5 fully paid, and partially paid £3. 10s.; and the character of the bargain was this, that up to 5 per cent. the £5 was to receive its 5s., and the £3. 10s. was to receive its 3s. 6d. or 1s. in the pound. After that it was to be equal per share, which complicates the calculation; in fact, it makes a difference of about £1,770 in the calculation. If the fully-paid shareholders were entitled to receive 5 per cent. upon their paid-up capital, the amount of money to disburse would be that amount more than it is. Therefore, relatively, they get a little less dividend. I now move:—

"That in addition to the interim dividend at the rate of 6 per cent. per annum for the six months ended March 31, 1891, already distributed, a dividend at the rate of 6 per cent. per annum be and is hereby declared on the shares of the Company for the half-year ended September 30, 1891 (making 6 per cent. for the year), and of 5 per cent. for the twelve months ended September 30, 1891, free of income-tax, to be distributed in accordance with the provisions of Clause 77 of the Articles of Association."

Mr. LEYLAND seconded the motion, which was carried unanimously.

The CHAIRMAN: The next thing is the re election of the retiring Director. I apprehend there will be no question about that; Mr. Swan's name is so well known, his services to this Company have been so considerable, and he has so identified the name of Swan with the Swan United Electric Light Company (Limited), that he has, as a matter of course, quite apart from considerations of fitness, and a large holding in the Company, and, as everybody knows, great inventive and business capacity, a claim upon your sympathy.

Mr. J. C. STEVENSON, M.P., claimed the privilege of proposing the resolution before the meeting, having been long connected with the Company, and having been Chairman of the Newcastle Board, with which Mr. Swan's attention had first been taken up. He begged therefore with much pleasure to propose:—

"That Mr. J. W. Swan be and is hereby re-elected a Director of the Company."

Mr. C. TOOTH seconded the motion, which was passed unanimously.

Mr. SWAN having briefly expressed his acknowledgments,

The auditors, Messrs. Welton Jones and Co. were unanimously re-appointed.

A vote of thanks was afterwards accorded the Chairman and Directors.

The CHAIRMAN briefly responded, remarking that if they had not had the essential conditions of success—the support of those whom they represented—they could not have got so successfully through the many difficulties which they had had to encounter.

The proceedings then terminated.

Blackpool Electric Tramway Company (Limited).

The annual meeting of this Company was held on Saturday at the Tyldesley-road Schools, Blackpool, Mr. R. Horsfall (Chairman of Directors) presiding.

The CHAIRMAN, in moving the adoption of the report published in our last issue, said he thought the results of the past year had been most satisfactory, both as regarded their finances, the condition of their works, and, in fact, everything else. The only item showing an increase was that of wages, which increase was occasioned, to a great extent, by the sand nuisance at the south end of the town. This inconvenience was largely increasing every year, and during the last twelve months they had had a good deal of trouble with it.

The motion, having been seconded, was unanimously adopted.

The retiring Directors, Messrs. Horsfall, Bickerstaffe, and Broadbent (Managing Director), having been elected,

Mr. HOYLE proposed a vote of thanks to the Directors for their services; and, referring to the 18th clause of the Towns Improvement Bill, dealing with powers over tramways, &c., expressed the opinion that the Corporation already had powers enough, and he trusted they would oppose the Corporation having any more powers touching their (the Tramway Company's) property.

The motion was carried unanimously.

Mr. J. P. Taylor was re elected auditor to the Company.

This concluded the ordinary business, but the meeting afterwards had a private sitting to consider the Towns Improvement Bill as it affected the Company.

NEW COMPANIES, STATUTORY RETURNS, &c.

ALMERIA AND ALHAMILLA RAILWAY COMPANY (LIMITED).—This Company was registered on the 18th November, 1891, with a capital of £100,000, in £5 shares, by Messrs. Ingledew, Ince and Colt, St. Benet Chambers, Fenchurch-street, E.C. The objects are:—To purchase the concession and works of the railway at Sierra Alhamilla to the dock of Almeria, in Spain; to carry on the business of a railway company generally, to acquire the right to use or manufacture and put up telephones, telegraphs or other electrical apparatus, whether for lighting, signalling or telegraph purposes, and for other purposes. Registered office: 108, Bishopsgate-street, E.C.

DE WINTON AND CO. (LIMITED).—This Company was registered on November 20, 1891, with a capital of £20,000, in £10 shares, by T. T. Hull, 22, Chancery-lane, W.C. The objects are:—To acquire and carry on the business of ironfounders, engineers, manufacturers of marine and other engines, carried on by J. P. de Winton and O. Thomas, at Carnarvon and elsewhere. The first Directors are J. P. de Winton, O. Thomas, and R. Parry-Jones. Solicitor: C. H. Rees, Carnarvon.

ELECTRICAL FINANCE CORPORATION (LIMITED).—This Company was registered on November 18, 1891, with a capital of £100,000, divided into 19,800 ordinary and 200 founders' shares of £5 each, by C. G. Baker, 22, Great George-street, Westminster, S.W. The objects are:—To construct, contract for, establish, and carry on, or to finance and provide capital for companies having for their objects the supply of electric light, power, and heat, and the production, transmission, storage, and use by any means and for any purpose of light, heat, electric, magnetic, or other force. The subscribers are:—

	Shares.
W. Martin, 12, Poplar-grove West, Kensington Park	1
R. Brooks, Sutton-on-Sea, Lincolnshire	1
A. T. Havers, 27, The Grove, Vauxhall, S.W.	1
Miss A. E. Munro, 42, Gordon-road, Stoke Newington	1
C. H. Venning, 24, Bromley-grove, Shortlands	1
F. Evershed, Forest Hill Tavern, Forest Hill-road, Peckham Rye	1
J. H. Infield, 10, Bolton-gardens West, S.W.	1

The number of the Directors is not to be less than three nor more than nine, the first to be appointed by the signatories, in writing. Qualification, forty £5 shares, or £200 stock. Remuneration, £100 per annum each and £100 extra per annum for the Chairman, and an addition of £100 each per annum whenever the profits remaining available for dividend amount to more than 10 per cent., provided that not more than £1,000 be paid in any one year, except in pursuance of a resolution passed at a general meeting.

HEATHER, BAILEY AND CO. (LIMITED).—This Company was registered on November 18, 1891, with a capital of £10,000, in £25 shares, by C. Doubble, 14, Serjeants'-inn, Temple, E.C. The objects are:—To carry on the business of builders and contractors; and to construct, maintain, develop, work, contract and manage electric connections and other works; heat and light supply works, telegraph and telephone connections and works, &c. Messrs. J. Rawle, J. Harris, J. Parry, T. Bailey, C. Beale and A. Stromquest are the first Directors.

INTERNATIONAL ELECTRIC SUBWAY COMPANY (LIMITED).—This Company was registered on November 17, 1891, with a capital of £25,000, in £1 shares, by Messrs. John Hart and Holmes, 22, Great Winchester-street, London, E.C. The objects are:—To acquire, work, and develop patents or patent rights connected with electrical underground conduits, electricity, electric machines, &c.; to enter into or acquire and carry out contracts for the supply of conduits, tunnels, or subways for the protection of electric wire; to enter into and carry out contracts for the supply of electricity and electric power, and for electric lighting; to acquire, develop, and carry on the business of manufacturers, suppliers, fixers, and fitters of electrical machinery and apparatus, electric generators and accumulators; to manufacture, use, instal, and maintain telephones, phonographs, telegraphs, and other electric apparatus. The number of Directors is not to be less than two nor more than five, the first to be appointed by a majority of the subscribers to the Memorandum and Articles of Association.

P. R. JACKSON AND COMPANY (LIMITED).—This Company was registered on November 19, 1891, with a capital of £120,000, in £10 shares, by Cooper, Dennison, and Co., 5, Shoe-lane, E.C. It intends to acquire and take over as a-going concern the business of steel and iron founders, engineers, and millwrights, now carried on by Mr. R. N. Jackson, at the Salford Rolling Mills, Hampson-road, Salford, Manchester, and to carry on such business in all its branches. The number of Directors is not to be less than three nor more than seven.

JOHANNESBURG LIGHTING COMPANY (LIMITED).—This Company was registered on the 20th November, 1891, with a capital of £150,000, in £1 shares, by Ashurst, Morris, Crisp and Co., 17, Throgmorton-avenue, E.C. The objects are to acquire and carry on the business of the Johannesburg Gas Company (Limited); to manufacture, sell and supply gas

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and electricity for lighting, heating, motive power, and other purposes, in the town of Johannesburg, and the suburbs thereof, the South African Republic and elsewhere in Africa; and to construct, manufacture, and maintain works and stations for holding, receiving, and purifying gas and generating and supplying electricity. The subscribers are:— Shares.

W. F. Lance, 7, Grote's-place, Blackheath	1
W. G. Soper, Bury-street, St. Mary Axe, E.C.	1
A. Jones, Bury-street, St. Mary Axe, E.C.	1
W. H. Adams, 168, Friern-road, East Dulwich	1
E. T. Botwright, 11, Oxford-road, Gunnersbury	1
W. B. Butler, 2A, Sixth-avenue, W.	1
W. J. Yeoman, 89, Brayard-road, Queen's-road, S.E.	1

The number of Directors is not to be less than three nor more than seven, the first to be appointed by the above subscribers. Qualification, £250; remuneration, £100 per annum each, and £100 additional for the chairman.

NEWMANS (LIMITED).—This Company was registered on the 19th November, 1891, with a capital of, £50,000, in £10 shares, by Bonner, Wright, Thompson and Co., Ingram House, 165, Fenchurch-street, E.C. The objects are:—To acquire, develop the resources of and turn to account land, mines and real or personal property of every description: to construct, maintain, improve, develop, and work any electric power, heat, and light supply works, telephone works, &c.

PEACOCK'S PATENT STEEL GRIP, LOCK, NUT, AND FISH BOLT SYNDICATE (LIMITED).—This Company was registered on the 18th November, 1891, with a capital of £30,000, in £1 shares, by Waterlow and Sons (Limited), 85, London-wall, E.C. The objects are to acquire the benefit of a certain existing invention, particulars of which are not given, and to carry on the business of iron founders, mechanical and electrical engineers, tool makers, brass founders, metal workers, &c.

STAR TUBE COMPANY (LATE TAUNTON AND HAYWARD, LIMITED).—This Company was registered on November 19, 1891, with a capital of £50,000, in £5 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are:—To acquire and take over as a going concern the business of Taunton, Delmard, Lane, and Company (Limited), and to carry on the business of mechanical, chemical, electrical, scientific and general engineers, designers and constructors, founders, manufacturers, workers of and dealers in iron, steel, brass and other metals, &c. The number of Directors is not to be less than three nor more than seven, the first to be appointed by the signatories to the Memorandum and Articles of Association.

SUTTON'S PROCESS SYNDICATE (LIMITED).—This Company was registered on November 18, 1891, with a capital of £15,000, in £1 shares, by Gerrish and Foster, 26, College-street, E.C. Objects:—To acquire from H. Sutton certain letters patent for "An improved process for converting a photographic image on a gelatine surface into a relief or intaglio printing surface," and to carry on the businesses of inventors, photographers, chemists, plate and metal manufacturers, printers, electrotypers, engravers, electricians, telegraphists or photo-telegraphists, &c.

SWANSEA CHEMICAL COMPANY (LIMITED).—This Company was registered on November 19, 1891, with a capital of £30,000, in £100 shares, by Witherby and Co., Newman's-court, Cornhill, E.C. The objects are to carry on the business of chemical manufacturers, including the manufacture and sale of sulphuric acid, hydrochloric acid, oxalic acid, salt cake, artificial manures and any other chemicals or chemical products.

WILSON AND LONGBOTTOM (LIMITED).—This Company was registered on November 19, 1891, with a capital of £16,000, in £10 shares, by Waterlow and Sons (Limited), London-wall, E.C. The objects are:—To acquire and carry on the business of Wilson and Longbottom, of the Nelson Foundry, Barnsley, and to carry on the business of mechanical engineers, machine and engineering tool makers, boiler makers, iron and brass founders, millwrights, metal workers, steel converters, colliery owners, metallurgists, and manufacturing chemists.

CROMPTON ELECTRIC SUPPLY COMPANY OF AUSTRALIA (LIMITED).—The annual return of this Company, made up to November 10, 1891, was filed on the 17th following The nominal capital is £50,000, divided into 9,500 A and 500 B shares of £5 each; 3,115 A and 500 B shares have been taken up, the 500 B shares being issued as fully paid. The A shares have had the full amount called, and £13,765 has been paid, leaving £1,810 unpaid. Messrs. Crompton and Co. (Limited), of Mansion House-buildings, E.C., hold 993 A shares. Registered office: Mansion House-buildings, Queen Victoria-street, London, E.C.

ELECTRIC DATE AND TIME STAMP COMPANY (LIMITED).—The annual return of this Company, made up to August 11, 1891, was filed on November 17, 1891. The Company was registered on April 13, 1888, to acquire and develop the invention of an electro-mechanical date and time stamp, and now has a capital of £121,000, divided into 100,000 original and 21,000 new shares of £1 each; 6,893 original and 21,000 new shares have been taken up, and upon 2,393 of the original shares the full amount has been called, and, with the exception of £122. 10s., paid. The remaining 4,500 original and 21,000 new shares have been issued as fully paid. Registered office: New Broad-street House, New Broad-street, London, E.C.

ELECTRICAL INVENTIONS COMPANY (LIMITED).—The statutory return of this Company, made up to the 6th November, 1891, was filed on the 21st following. The Company was registered on the 18th September, 1890, to acquire, develop, and deal in patents for electrical inventions, and had a capital of £35,000, in £1 shares. Seven shares only are taken up, upon which nothing has been called, the original signatories being the only shareholders. No agreements for the taking over of any concessions, businesses, patents, &c., have been filed, and no office registered.

MONTE VIDEO TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to the 13th November, 1891, was filed on the 17th following. The Company, which was registered on the 31st July, 1888, has a nominal capital of £220.000, divided into 29,000 preference and 15,000 ordinary shares of £5 each. 28,000 preference and 15,000 ordinary shares have been taken up, of which 3,000 preference and 3,000 ordinary were issued as fully paid. Upon the remaining 25,000 preference and 12,000 ordinary the full amounts have been called and paid, realising £185,000. Only 1,000 out of the 44,000 shares are at present unissued. Registered office: 25, Abchurch-lane, E.C.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts of this Company for the week ended November 22nd amounted to £792; aggregate receipts for half-year to date, £15,157.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The Stock Exchange Committee have ordered ordinary shares Nos. 40,001 to 70,152 to be quoted in the Official List.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—Notice is given that 312 £5 per Cent. Mortgage Debentures of this Company have been drawn for payment at par on January 1st next at Messrs. Barclay, Bevan and Co.'s, 54, Lombard-street, E.C. Further particulars will be found in our advertisement columns.

ELECTRICAL UNDERGROUND RAILWAY BETWEEN FINSBURY PARK AND THE CITY.—Parliamentary notice has been given by a new company of its intention to promote a Bill in the next Session for powers to construct an electrical underground railway, commencing by a junction with the Great Northern Railway at Finsbury Park, and terminating in the City about the centre of Finsbury Pavement. Powers will also be sought to run into and use the Finsbury Park Station of the Great Northern Railway Company.

HALIFAX AND BERMUDAS CABLE COMPANY (LIMITED).—The following has been issued to the holders of the Four and a-Half per Cent. Debentures of the Halifax and Bermudas Cable Company (Limited), 33, Old Broad-street, London, E.C.:—"It has been brought to the notice of the trustees of the £120,000 Four and a-Half per Cent. Debentures of this Company that the investments to be made on behalf of the sinking fund for the redemption of the principal sum at the end of 20 years—when the subsidy expires—is so restricted under the trust deed that the result must be a deficiency of about £30,000, while the Company's circumstances would not justify the assumption that that large sum could be provided from other sources. In the interest of the bondholders it is, therefore, imperative to give the trustees larger powers towards this end. At present the choice is limited to such securities as a trustee may select under the Statute, and the yield from such investments would be about 2¾ to 3 per cent. It is now designed to take power to apply the sinking fund to the redemption of the above Four and a-Half per Cent. Bonds, by purchase when the bonds can be got under par, and by drawings when the price is par or above. By this modification the redemption of all the bonds within the term of the subsidy would be practically assured, and the application of the sinking fund to purchases or drawings would further benefit the bondholders by tending to remove the discount at which the bonds now stand. But this modification of the trust deed can only be effected with the consent of the bondholders; and you are, therefore, requested to signify your concurrence in it.—HENRY BRUDENELL BRUCE, C. SEYMOUR GRENFELL, Trustees for the Bondholders."

NATIONAL TELEPHONE COMPANY (LIMITED).—The Stock Exchange Committee have ordered the provisional certificates (partly paid) of a further issue of £250,000 Four and a-Half per Cent. Debenture Stock to be quoted in the Official List.

SPANISH NATIONAL SUBMARINE TELEGRAPH COMPANY (LIMITED).—The numbers are announced of 83 bonds of £100 each of the Six per Cent. Morgage Debentures, to be paid off at par on and after December 31st next at the National Bank of Scotland, Nicholas-lane, E.C.

VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY (LIMITED).—The first ordinary general meeting of this Company was held on Tuesday, when a dividend at the rate of 4 per cent. per annum was declared on the shares of the Company for the half-year ended June 30th.

WATERLOO AND CITY RAILWAY.—Amongst the Parliamentary notices advertised this week is that of the Waterloo and City Subway, or Railway, for which application will be made to Parliament in the ensuing Session for a Bill to enable the Company which will be formed to undertake the construction and maintenance of an underground railway or subway, for the conveyance of passengers, goods, and animals. The railway is to commence in the parish of St. Mary, Lambeth, and to terminate in the parish of St. Mary Woolchurch, in Mansion House-street, E.C., opposite the north-eastern corner of the Mansion House. The gauge to be adopted for the railway will be 4ft. 8½in., and the motive power is to be electricity or cable. The usual powers are asked for, one of which is to empower the Company on the one hand, and any company or person authorised to supply electricity in any district in which any part of this railway or subway will be situated, or the London and South-Western Railway, on the other hand, to enter into or carry into effect

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agreements with respect to the supply of electricity or electrical energy or power. As usual, plans and sections of the railway proposed to be authorised under the Bill, showing the lines and levels thereof, the lands to be purchased or acquired by compulsion, and a book of reference to such plans, will be deposited for public inspection with the Clerk of the Peace for the County of London, at the Sessions House, Clerkenwell, E.C., and the Clerk of the Peace for the City of London, at the Sessions House, Old Bailey. This, of course, is in addition to the copy of such portion of the plans, sections, &c., as relate to the various localities through which the railway will pass, which will be deposited with the Vestry Clerks of the several parishes. Messrs. Rees and Frere, of 13, Great George-street, Westminster, are the Parliamentary agents for the Bill; and Messrs. Bircham and Co., of 46, Parliament-street, Westminster, are the solicitors.

WOODHOUSE AND RAWSON UNITED (LIMITED).—"It is somewhat strange," says the *Economist* of Nov. 21st, "that at the meeting of the shareholders in this Company, which was held last Friday, no mention was made of the further issue of capital, amounting in all to £165,000, which has since been offered by public advertisement. We have no means of judging to what extent the invitation of the Directors has been successful; but it is not easy to understand why the public should pay a premium of 5s. per share on the new ordinary shares and par for the preference shares and debentures, while the different classes of the Company's securities are quoted at from 20 to 50 per cent. discount. Woodhouse and Rawson United is one of those undertakings in which the proprietors appear to care little about financial stability so long as large dividends are forthcoming. Ostensibly, its business is the manufacture and sale of electrical plant and machinery, and the report recently presented states that the net profit of the supply department had doubled in the year; but the report and the accounts are alike silent as to what amount has been earned by the legitimate operations of the Company, and what by the promotion of Elmore copper."

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Nov. 18.		Price Wednesday, Nov. 25.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Nov. 25.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/6	Anglo-American	48	49	48½	49½	5 4 0	Jan., Apr., July, Oct.	49⅝	..
£2,849,510	Stock	25/0	Do. Preferred	86	87	86½	87½	5 17 3	" "	87⅜	86½
£2,849,510	Stock	5/0	Do. Deferred	12	12½	12	12½	..	" "	12⅜	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	..	..
130,000	£10	5/0	Brazilian Submarine	10½	11	10½	11	7 5 6	Mar., June, Oct., Dec.	11	10
£69,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	140	145	140	145	4 16 7	April and October	145	143
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	10	..
6,000	10	10%	Do. Preference 10%	16⅜	17½	16	17	5 17 8	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3	3½	3⅛	3⅜	6 18 8	April and October	3⅜	..
6,000	5	10%	Do. Preference 10%	9½	10½	9⅜	10⅜	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10⅝	10⅞	10⅛	11	6 7 3	Jan., Apr., July, Oct	10⅛	10⅛
400,000	10	2/6	Eastern	13⅜	14⅜	14	14⅛	4 11 3	" "	14⅛	14
70,000	10	6%	Do. 6 per Cent. Preference	14⅛	15⅛	14⅛	15⅛	8 18 8	" "	15	14
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	108	106
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	108	107
250,000	10	2/6	Eastern Extension	14⅜	15	14⅜	15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	14⅜
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	106	109	107	110	3 12 9	February & August	108	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	102	105	102	105	4 15 8	" "	105	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd)	98	101	98	101	3 19 3	January and August	..	..
180,227	10	2/0	Globe Telegraph and Trust	9⅜	9⅞	9⅜	9⅞	5 8 10	Jan., Apr., July, Oct.	9⅞	9⅜
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	14⅞	14⅜	14⅞	4 0 8	" "	14⅞	14⅜
150,000	10	5/0	Great Northern	18½	18⅝	18½	19	4 9 6	Jan., April, and July	18⅞	18½
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	..	..
38,348	10	4/0	London Platino-Brazilian xd	6	7	6	7	6 8 7	" "	6	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	107½	..
9,000	8	4/0	Reuter's	7½	8½	7⅜	8½	4 16 11	April and October	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	118	123	117	122	4 18 4	" "	117½	..
15,609	10	6/0	West African Telegraph	7½	8½	7½	8½	5 17 8	January and July	..	..
£231,400	100	5%	Do. 5 per Cent. Debentures	96	99	96	99	5 1 0	March & September	97½	..
30,000	10	2/0	West Coast of America	2	3	3	4	..	January and July	4	2⅛
£150,000	100	8%	Do. Debentures 8% 1902	97	102	97	102	7 16 10	June and December	..	..
88,321	10	9d.	West India and Panama	1⅛	1⅜	1⅛	1⅜	..	May and November	1⅛	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	8⅜	9⅛	8⅜	9⅛	6 9 9	" "	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7⅛	8⅛	7⅛	8⅛	7 1 2	" "	..	..
61,683	15	9/0	Western and Brazilian	10	10⅛	10	10⅛	7 2 10	" "	10⅛	9⅜
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½	7	6½	7	5 7 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	3⅜	4⅛	3⅞	4⅛	..	" "	4	3⅛
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	101	107	103	106	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	121½	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	1⅞	1⅝	1⅞	1⅝	7 9 4	May and November	½	..
220,000	£1	4·76d.	Oriental (11s. paid)	1⅝	1⅝	1⅝	1⅝	6 8 11	Yearly	..	..
433,984	5	3/6	National	4⅜	4⅝	4⅜	4⅝	6 9 9	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13	12½	13	4 12 4	" "	..	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12	13	12	13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	108	108	107	109	4 2 7	..	108⅜	107½
58,000	5	1/0	United River Plate	1	2	1	2	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 Sh.)	4⅛	4⅜	4	4¼	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
5,322	£5	..	House to House Electric	4½	5	4½	5	..	..	..	..
30,000	£5	3½	Liverpool Electric Supply (£3 paid)	2⅜	2⅝	2⅜	2⅝	..	March and February	..	..
10,000	5	3½	Do. (fully paid)	4⅜	5½	4⅜	5½	..	" "	..	..
111,000	£5	..	London Electric Supply	1⅞	2⅛	1⅞	1⅞	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	10	10⅛	10	10⅛	..	..	10⅜	10⅛
6,318	10	..	Notting Hill Electric Lighting (fully paid)	6	7	6	7	..	..	..	..
7,730	£5	3/6	St. James' and Pall Mall	8⅜	9⅛	8⅜	9⅛	..	..	9⅛	9
..	..	7%	Do. 7% Preference	7⅛	7⅜	7⅛	7⅜	..	..	7⅜	..
42,853	5	..	Westminster Electric Supply (£5 paid)	6¼	6⅜	6¼	6⅜	..	..	6 1/16	6 1/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/8	Brush Electrical Engineering	3⅜	3⅝	3⅜	3⅝	4 19 9	..	3⅛	3⅜
69,996	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 2 8	..	2⅛	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5	5⅛	5	5⅛	6 7 3	January and July	..	..
17,139	5	..	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	6%	Electric Construction	6¾	7⅛	6⅝	7⅛	..	—	7⅛	6⅝
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅞	3⅛	2⅞	3	..	—	3 1/16	2⅞
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20½	21½	20½	21½	4 15 3	February & August	21⅜	21
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	6	7	6	7	..	January and July	..	..
11,334	£10	8/0	Do. Preference	8½	9½	8⅜	9½	8 13 6	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅜	⅝	⅜	⅝	..	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4½	4⅝	4½	4⅝	8 2 0	May and November	4 1/16	4½
37,350	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July	43½	42½
50,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2⅛	2⅜	2⅛	2⅜	15 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	3⅜	3⅝	3⅜	3⅝	10 0 0	..	..	..
			RAILWAYS AND TRAMAYS.								
£2,850	10	7½	Blackpool Electric Tramway	..	..	..	..	—	—	—	..
50,000	£10	..	City and South London Railway	3	5	3	5	—	—	—	..

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THE ELECTRICIAN:

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NOTES.

The Paper on electrical measurements by Captain Sankey and Mr. Andersen has been somewhat hastily undervalued in some quarters because it contains little if anything that is new. It was, however, an excellent example of a case in which the chief use of the Paper was to provoke discussion; and though this may not have been the object of the authors, such discussion as there was was distinctly useful, and if it had been more general would have been of considerable value. The remarks of Prof. Ayrton, on the other hand, offered an example of misplaced effort. Exactly the same information in the shape of a Paper would have formed an excellent supplement to the one read, since, if time had been allowed, a good discussion might have been raised upon it. That time is required is a consequence of the importance of the subject; it is easy enough to discuss a simple or trivial matter on the spur of the moment.

An important Paper on galvanometers (of which Prof. Ayrton was one of the joint authors) was read before the Physical Society in January, 1890 (*The Electrician*, Vol. XXIV., p. 348). This was similarly very ineffective, provoking as it did only a very superficial discussion, and one quite unworthy of the contribution. That Paper contained the first and the last reference that has been made to a "factor of merit" of galvanometers. It attempted to classify galvanometers into four divisions, depending on the strength of the fields. A factor of merit of a single class of instrument of a certain definite type, and intended for a certain definite purpose, would have some value; and a discussion on such a point would have been very interesting in connection with Capt. Sankey's Paper.

Mr. Siemens may be right in saying that instead of wishing electrical measurement for workshop purposes might partake less of a laboratory character, it should be a matter of congratulation that electrical engineering was becoming so scientific that these methods are well suited to it. But if this should be the case, the requirements and the degree of accuracy in the workshop are so different from those of the laboratory, that there is a good deal to be said about the adaptation of methods and apparatus used in the one, for the special purposes of the other. The time has now come for a thorough discussion on electrical measurements for engineering purposes. Professor Ayrton should write a short Paper, Mr. Crompton another, and some instrument-maker—Mr. Crawley, for example—a third. They should all be printed, including illustrations, and well circulated a few days before reading. On the 17th of last month three Papers were read on the same subject at the Institution of Civil Engineers—much shortened, of course, and were discussed together on two subsequent evenings.

We alluded some weeks ago to the fact that Prof. Ewing was investigating the subject of the iron losses in transformers. His experiments have just been described before the Physical Society of Cambridge, and our readers will find an account of them printed in another column. They appear to settle the question whether the hysteresis losses in a transformer alter with the load to which it is subjected, for they show that these losses are practically constant at all loads, while the transformer is worked under conditions of constant induction or voltage. This has always been the common opinion; but, when the question of its accuracy was once raised, it became necessary to investigate the matter experimentally, as no one could predict the influence of magnetic leakage at different loads. As we have previously pointed out, the great difficulty of the investigation arises in finding a satisfactory method of measuring the iron losses directly; and Prof. Ewing has completely overcome this obstacle in a very ingenious way, so that, in spite of the fact that his transformer is a mere toy in point of size, there seems no reason to doubt the correctness of his result.

Curiously enough, very shortly after Prof. Ewing designed his method of directly measuring the power lost in transformer cores, an entirely different method was published in America. This method is described by Mr. T. Spencer in our excellent contemporary, the New York *Electrical Engineer* for November 11th, and it depends upon the use of a dynamometer of special construction. The instrument possesses two stationary coils and one movable coil. The primary current of the transformer is sent through one of the stationary coils, while the secondary current is sent through the two in series. The winding of the coils has to correspond with that of the transformer tested, and, under these conditions, the reading of the instrument measures the power lost in the iron. The method seems perfect enough theoretically, but it has the great practical defect that, while the coils of the dynamometer must be suitable for the passage of large currents, the actual magnetising effect causing the deflection will be merely that due to a very small current,

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owing to the opposition of the currents in the two fixed coils As dynamometers are not very sensitive instruments under favourable conditions, the use of them in this manner can hardly prove satisfactory.

The reading of Mr. Robertson's Paper on "Secondary Batteries," or, as he prefers to call them, "reversible batteries," before the Society of Arts on Wednesday evening, brought together a large number of accumulator experts, who were unanimous in congratulating Mr. Robertson on his discovery of the important part played by hydrogen dioxide (H_2O_2) in the economy of the Planté lead-sulphuric acid—lead peroxide cell. In support of the contention that the variations of electromotive force depend on which plate the hydrogen dioxide is formed at, a pretty little experiment was performed, which was, unfortunately, visible only to the respected chairman. A miniature reversible cell, with one of its electrodes in a porous pot, was charged up and connected to a sensitive voltmeter, which showed the abnormally high electromotive force usual in a freshly charged cell. On interchanging the electrodes, taking the peroxide plate out of the liquid rich in dioxide, and placing the plain lead plate there instead, the voltmeter index immediately fell back several points. The importance of H_2O_2 having now been proved, it is for those who want all they have now with half the dead weight to see if they cannot turn the discovery to some practical account.

The Paper on the candle-power of glow lamps, read at the American Academy of Arts and Sciences, and reprinted in our present issue, deals with a matter of great importance; and it is to be regretted that no specimens of English-made lamps were included, not for comparison with other kinds, but because that is the only make with which we are concerned in this country. It is obvious that all such information as is contained in this Paper, and much more, relating to life, is well known to the scientific officials of the Edison-Swan Company, but is jealously guarded as a profound secret. Important as the subject is, there is naturally some apathy about it, because we have no choice but Edison-Swan lamps for ordinary candle-powers, and it is therefore hardly worth while troubling about tests. We have omitted numerous tables and records of tests, because, in the absence of tests of Edison-Swan lamps, the Paper is of only general interest to our English readers.

The correct title of the society to which Mr. Oliver Heaviside alludes at the conclusion of his interesting and useful article this week is the Association for the Improvement of Geometrical Teaching. It was founded, we believe, about ten years ago by a few teachers, who realised that Euclid for children is, as Mr. Heaviside puts it, simply barbarous. Three pamphlets have been published by Messrs. Macmillan and Co.—a syllabus of plane geometry, corresponding to Euclid, Books I. to VI.; another of modern plane geometry; and another of linear dynamics. Messrs. Swan, Sonnenschein and Co. have published an elementary geometrical conics, and there the labours of the Association appear to have stopped. The Association has to struggle against the stubborn conventionalism of the modern schoolmaster, who pleads that he cannot make any change, because of the Universities. After a considerable fight, Mr. Hamblin Smith's common-sense proofs of Euclid's problems were accepted by Cambridge examiners. Small as the visible results of the Association have been, there is a distinct change of feeling taking place with regard to geometry, both as an educational subject and as an implement of scientific work. At present geometry is taught as badly as Greek, even in the best public schools; and the educational value of Greek is in many respects higher than that of Euclid.

An apparatus for transmitting drawings by telegraphy is described in a recent number of *Electricity* of Chicago, and reproductions are given of some attempts to reproduce photographs. Caselli and others worked with more or less success at this problem. Several instruments were shown in operation at the Electrical Exhibition at Paris in 1881, and more than one writing telegraph has been devised. Unfortunately there is no practical demand for anything of the kind. More than a year and a-half ago an apparatus was designed in this country, by which a sketch drawn on tin could not only be transmitted by a single line, but a block of type metal could be engraved at the receiving end, ready for printing, at the rate of about one square inch per minute. Experiments were made, and the results were very promising, but on making inquiries it was found that nobody wanted such a thing—not even the *Daily Graphic* cared to consider it. Like many other scientific novelties, it had no commercial value, and the patent was abandoned. This invention, as well as the writing telegraph, is sure to turn up periodically.

The *Glasgow Herald* of the 28th ult. contains about a column of closely-printed matter, embodying charges of obstructiveness or incompetency on the part of the telegraph authorities in London, who, it seems, have been guilty of rejecting the advice of the writer, or the people whom he represents. He alleges that Glasgow is badly served telegraphically, and roundly appeals to its citizens to see that their grievances are redressed. For one who complains that not only are appeals to "London" of no avail, but that resort to the Press is denied him, this is going rather far. No doubt the "St. Martin's-le-Grand people" will take due note of it. The writer evidently is well informed, but he surprises us rather on one point, though, being a Scotchman, as unquestionably he is, his intense self-sufficiency requires some discounting. He states that under ordinary circumstances all the Glasgow wires are worked by key. If that be the case, no wonder the people in London think Glasgow has wires enough, although the *Glasgow Herald's* prompter does not; and when he goes on to say that on the Wheatstone automatic being resorted to at times of pressure, the London office is not up to the work, the writer rather staggers us, though the statement does not. To read Wheatstone slip is the easiest thing in the world; but to prepare Wheatstone slip for transmission is far from

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easy; and if, as is admitted, Glasgow rarely practises punching, it is not surprising that when the automatic has to be used, long delays occur through repetitions and inability to decipher in London what has been transmitted from Glasgow, admirable though the operators at that office may be on the key.

Electric Traction at Spezzia.—It is intended to use electricity on a tramway shortly to be constructed by a Belgian Company at Spezzia.

The Telegraph in Mashonaland.—The 200 miles of telegraph line, which have still to be laid to Fort Salisbury, will be completed before the rains begin.

King's College.—A new course of evening electrical engineering lectures and laboratory work will begin at this College on Monday, January 18th.

Cable Communication with Spain.—The Direct Spanish Telegraph Company inform us that direct cable communication with Spain (*via* Bilbao) is restored.

Telegrams to Peru.—Telegrams can now be forwarded to Peru by the routes of the Eastern and Direct Spanish Telegraph Companies, at the rate of 8s. 2d. per word.

The Cadogan Electric Light Company.—This Company will, we understand, commence the new year by adopting the three-wire system with secondary batteries.

Dublin.—Rapid progress, says the *Freeman's Journal*, is being made with the construction of the central station, which is to light this city. It is hoped that the entire work will be completed by next April.

Glasgow.—The Electric Lighting Committee of the Town Council have acquired a site on which the necessary plant will be erected for lighting the central area. The price paid is about £8,000, or between £7 and £8 per square yard.

Brighton.—The Brighton and Hove Electric Light Company give notice of their intention to apply for a Provisional Order authorising them to lay down mains, but not erect overhead wires, in every part of the borough not supplied by the Corporation.

Plauen.—According to the *Elektrotechnischer Anzeiger*, an electric tramway two miles in length is to be built in Plauen. The project, plans for which are being prepared by Messrs. Schuckert and Co., also includes the erection of a central station for lighting.

Interurban Telephony.—A new line has recently been constructed by the Western Counties and South Wales Telephone Company between Tewkesbury and Cheltenham; and during one of the trials of the line some 700 words are said to have been spoken in three minutes.

Appointment Vacant.—The Committee of University College, Nottingham, invite applications for the post of Demonstrator in Electrical Engineering. New engineering schools have been erected, and the appointment should prove an important one. Further particulars are given in our advertisement columns.

A Cable to the Bahamas.—Arrangements have been made for connecting, under subsidy, the Bahama Islands in the West Indies with the general telegraphic system of the world by means of a submarine cable of about 200 miles in length. The cable is being manufactured by Messrs. W. T. Henley and Co., and will be laid in January or February next.

Institution of Electrical Engineers.—A meeting of the students of the Institution was held on Friday, November 27th, when a paper was read on "Electric Mains for the Distribution of Light and Power," by Messrs. Griffin and Minshall. The next meeting will be held on Friday, December 11th, when a paper will be read on "Measuring Instruments," by Mr. W. A. Vignoles.

Nottingham.—Having consulted Dr. J. Hopkinson and Mr. W. H. Preece, the Electric Lighting Committee of the Town Council unanimously recommended that the Town Council should undertake the electric lighting of the borough under their Provisional Order. The Committee add they do not think that for some time to come the supply of electricity to the borough could be made a source of profit.

The Application of Electricity to Mining.—On Saturday afternoon last week the first of a series of seven lectures on this subject was delivered in the Guildhall, Derby, under the auspices of the Midland Counties Branch of the National Association of Colliery Managers and the Derbyshire County Council. The lecturer was Mr. George Fletcher, head master of the Science Department of the Derby Technical College.

Mr. Cyrus Field.—Mr. Field, who has been hovering between life and death since his wife died, was reported to be in a slightly improved condition on Wednesday, having rested well the previous night. He was, however, still in an exceedingly critical state. The latest information by special message is that "he is slightly improved this (Thursday) morning." Mr. Field's daughter is at the present moment dangerously ill, and only a few days ago the firm in which his son, Mr. Edward Field, is a partner, was declared insolvent.

Electric Traction at Croydon.—On Monday afternoon Major-General Hutchinson and Major Cardew visited Croydon for the purpose of inspecting, on behalf of the Board of Trade, the working of an electric car, several similar to which are about to be adopted by the Croydon Tramways Company. The car, which, when empty, weighs 5½ tons, is driven by two motors of 14 H.P. and can attain a maximum speed of 16 miles an hour. A trial trip was made to Thornton-heath, after which the whole of the circuit to North-end, Croydon, was completed without a hitch, and the inspectors expressed themselves as being thoroughly satisfied with the experiment. The car has been built by the Electric Tramcar Syndicate.

The Berliner Microphone.—With reference to the Berliner microphone it may be interesting to note that in November, 1878, a Mr. F. T. J. Haynes, of Taunton, described in the *Somerset County Gazette* a microphonic transmitter very similar to that originally described in the *Scientific American*:—"The instrument consists of a diaphragm made of ferrotype plates fastened in a vertical position. In the centre of the diaphragm a piece of carbon is secured. The base of the carbon is against the back of the diaphragm, and its point rests lightly against another piece of carbon, which is fixed on the top of a brass spring. There is a screw in the rear of the spring for adjusting purposes. This simple instrument, when connected to a telephone and battery, will transmit articulate and other sounds distinctly." Readers who may be interested in the genesis of the microphone will do well to consult Vol. I. of *The Electrician*, 1878.

Sir William Thomson.—On the occasion of the presentation of Sir William Thomson's portrait to the University of Glasgow, on Friday last, Principal Caird concluded his speech as follows:—"May I venture to add that, while we share in the admiration for his varied gifts that is felt for him by those who know him only by reputation, it would have been impossible to have been so long associated with him as I and my colleagues have been without having felt the singular charm of his personal character? In Sir William, I think, we have a remarkable exemplification of the modesty of true science. Amidst accumulating honours that would have turned many a wise man's head we have found him ever as simple, gentle, unpretending as he is able and accomplished. Therefore we accept the gift you have now offered to us with pleasure and with pride, as the portrait not only of one of the greatest of our teachers, but one of our most valued and accomplished friends."

The Brazilian Government and the Cable Service.—The Rio de Janeiro correspondent of *The Times*, in a letter dated November 9th, states that on the occasion of the latest revolution but one in that country, the Government prevented the sending of telegraphic messages unless the meaning was perfectly clear, and in several instances, even after they had been passed and handed in for transmission, the official took them away, thus causing considerable inconvenience to commercial houses, who in some instances were not aware till the following day that their cablegrams had not been despatched. Fortunately, the British and American Ministers strongly protested, and induced the Government to

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withdraw their "fiscal" from the cable office. On Sunday evening the Government again sent an official to the cable office to examine messages to and from the south, and this they are still doing. Nothing is definitely known as to their reasons for this, but it is surmised that at the present time fighting is taking place in Rio Grande. It is certain that the Government wires overland have been cut.

The Crystal Palace District Electric Supply Company.—We learn that most satisfactory progress is being made with this Company's installation, and that already the large building, the foundation stone of which was only laid on October 17th last, is roofed in and partly occupied with four 150 H.P. engines. The mains, so far as street work is concerned, are practically completed. Archer pipes have been selected. As our readers are aware, Messrs. J. E. H. Gordon and Co. are the contractors for the work, and the building work is being done by Mr. Fell, of Leamington. It will also be remembered that the Crystal Palace Company had to abandon that part of their district which was situate in Croydon; but we understand that, by a resolution recently approved by the Lighting Committee of the Croydon Corporation, a proposal from the Company to light Westow Hill and its immediate neighbourhood, has been agreed to, the Corporation reserving to itself the rights secured by its own Provisional Order. It will be seen from an account of the meeting of the Electric Installation and Maintenance Company appearing elsewhere in this issue, that that Company has changed its title, and becomes "The Crystal Palace District Electric Supply Company." These results are effected by the resolutions passed at the extraordinary general meeting held yesterday, and which will doubtless be confirmed at the special meeting called for the 19th instant.

Surveying for a Submarine Cable in the Pacific.—The United States steamer "Albatross," says the *Western Electrician*, has ended the first half of the survey of the bed of the ocean for a submarine cable between San Francisco and Honolulu, which was authorised by a special appropriation of $25,000 made by the last Congress. It is considered quite impossible to run a cable from San Francisco direct, for the reason that a plateau extends out for a distance of about 60 miles, with an average depth of only 100 fathoms; but at that point the depth suddenly increases to 1,200 fathoms, proving the existence of a precipice. The whole coast of California does not offer more than a half-dozen places suitable for a cable landing. But comparatively few stretches of sandy beach, free from outlying rocks, exist along the coast, and by far the greater portion of the shore waters are shallow, and the bottom is besprinkled with sharp rocky projections. In the Bill making the appropriation, Congress designated San Francisco as the point from which the cable should be laid, but a poorer location is not to be found on the Pacific coast. It happens, however, that the most eligible site existing is the one nearest San Francisco. This place, which is generally known as Moss Landing, though the Government charts designate it as Salinas Landing, is almost in the centre of the long, clear, sandy beach circling Monterey Bay, and at a point about one mile south of the mouth of the Salinas river. The bay has practically no shipping traffic, hence no injury is to be feared from dragging anchors.

Oxford.—The site selected for the Oxford central station is at Cannon Wharf, by the side of the river, and is in close proximity to the railway. The local authorities, says the *Engineer*, insisted upon a continuous-current system being adopted, and the distance from the station to the centre of the compulsory area, which is about 1,300 yards, necessitated the adoption of a high-pressure primary system, with transformers. The plant now to be installed consists of three locomotive multitubular boilers, working at 160lb. pressure, supplying steam to three vertical triple-expansion surface-condensing 135 H.P. engines. Each engine will drive a separately excited Elwell-Parker dynamo, having an output of 1,050 volts and 80 amperes. From the generating station two pairs of high-pressure cables will run to a switch station situated near the centre of the district to be lighted. The whole of the distribution and regulation of the supply will be carried out from this place. At the switch station these cables will connect on to a pair of omnibus bars, from which current will be supplied to continuous-current transformers, situated at the switch station and at various sub-stations throughout the district. The starting and stopping of the transformers is to be carried out entirely from the switch stations without any attention at the sub-stations. The transformers are each to have an output of 107 volts and 360 amperes, running at a speed of 550 revolutions, with an efficiency of 90 per cent. at full and 80 per cent. at one-third load. The station will, it is anticipated, be running for the supply of current early in the new year.—We understand that the Electric Installation and Maintenance Company has applied for powers to transfer its Oxford Order to the Oxford Electric Light Company.

The Chicago Exhibition.—Our Chicago contemporary, *Electricity*, in its issue of November 18th, contains the following remarks, under the heading of "A Strange Proceeding":—"The English Royal Commission, which has charge of all exhibits to the Fair from Great Britain and her colonies, has just raised a very important question. It has issued a circular informing all English exhibitors that they must pay for space in the World's Fair buildings at rates ranging from 60 cents to $1.20 per square foot. In their official notice, members of the Commission say that they are compelled to charge for space on account of the meagre appropriation of Her Majesty's Government. For months Director-General Davis has been sending printed matter to Europe, informing prospective exhibitors that no charge would be made for space in the buildings. When the English Commissioners were in Chicago he gave them 250,000 square feet free of charge, and promised to give them more if needed. Colonel Davis does not understand that the English Commission has any authority to collect money from exhibitors. He is now in correspondence with Sir Henry Trueman Wood, secretary, to learn why the charge is levied. Officials of the Fair believe the action of the English Board will injure the Exposition abroad, especially if the precedent should be followed by other countries. At the Paris Exposition no charge was made for floor space, but the managers made an assessment for 'flooring,' which caused much complaint."—A notice published in the *London Gazette* announces that the protective sections of the Trade Marks Act of 1883, in regard to inventions sent to an industrial or international exhibition, shall apply to the Chicago Exhibition of 1893, the exhibitors, however, being relieved from the conditions specified as to the giving notice of their intention to exhibit.

The Comparative Cost of Electric and Horse Traction on the Continent.—In a Paper recently read before the Vienna Society of Engineers, Herr H. Koestler gave some interesting figures with regard to the cost of electricity and horses for tramway work. We are indebted for our information to an abstract in *La Lumière Electrique*, of November 14th. The figures being mostly comparative have been left as in the original in car kilometres, and centimes per car kilometre; but to transform them into car miles and pence per car mile we have only to multiply them respectively by ·62 and ·16. Herr Koestler first of all compared the Moedling-Hinterbrühl electric line (4·5 km.) with the Liesing-Kalterleutgeben ordinary line (6·7km.), which are worked under almost identical conditions; the outgoings per car kilometre are respectively 31 and 25 centimes, and the net earnings 52 and 10·7 centimes. The next lines compared are the Frankfort-Offenbach electric line and the Frankfort horse-car system The gross receipts per car kilometre are respectively 33·75 and 67·15 centimes, total working expenses 30 and 59 centimes; net earnings, 3·75 and 8·15 centimes. It will be seen that the working expenses of electricity are 50 per cent. less than those of horses, but the large traffic on the horse lines turns the net balance in their favour. In January, 1890, the Budapest electric lines were 6 and the horse lines were 45·6 kilometres long, and the car kilometres run were respectively 291,262, and 5,440,400. The receipts per car kilometre were respectively 71·16 and 58 centimes, and the expenses respectively 35·5 and 43 centimes; so that what Herr Koestler terms the "exploitation coefficient" comes out at 74 per cent. for horses, and 50 per cent. for electricity; and even this is unduly favourable to the horse-cars. The Budapest horse-cars are, moreover, worked exceptionally cheaply; in Vienna, for instance, the exploitation coefficient is 92 per cent.

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ELECTROMAGNETIC THEORY.—XX.

BY OLIVER HEAVISIDE.

(*Continued from page 28.*)

§ 103. We should, in the first place, fix how to represent vectors, although in reality this is the outcome of experience. A vector may obviously be denoted by a single letter; and, having defined certain letters to stand for scalars and others for vectors, it is certainly unnecessary that the vectors should be distinguished from the scalars by the use of different kinds of types. But practical experience shows that it is very desirable that this should be done, in order to facilitate the reading of vectorial work, by showing at a glance which letters are vectors and which are scalars, and thus easing the stress and strain on the memory. This is all the more important because the manipulation of vectors sometimes differs from that of scalars.

Now Prof. Tait usually indicates vectors by Greek letters. But it is well known that a considerable familiarity with the Greek letters—such as is acquired by studying the literature of ancient Greece—is required before they can be read and manipulated with facility. On the other hand, few are Greek scholars, and in fact many people think it is about time the dead languages were buried. Greek letters are, at any rate, not very well adapted to a vector analysis which aims at practicality.

Maxwell employed German or Gothic type. This was an unfortunate choice, being by itself sufficient to prejudice readers against vectorial analysis. Perhaps some few readers who were educated at a commercial academy where the writing of German letters was taught might be able to manage the German vectors without much difficulty; but to others it is a work of great pains to form German letters legibly. Nor is the reading of the printed letters an easy matter. Some of them are so much alike that a close scrutiny with a glass is needed to distinguish them, unless one is lynx-eyed. This is a fatal objection. But, irrespective of this, the flourishing ornamental character of the letters is against legibility. In fact, the German type is so thoroughly unpractical that the Germans themselves are giving it up in favour of the plain Roman characters, which he who runs may read. It is a relic of mediæval monkery, and is quite unsuited to the present day. Besides, there can be little doubt that the prevalent shortsightedness of the German nation has (in a great measure) arisen from the character of the printed and written letters employed for so many generations, by inheritance and accumulation. It became racial; cultivated in youth, it was intensified in the adult, and again transmitted to posterity. German letters must go.

Rejecting Germans and Greeks, I formerly used ordinary Roman letters to mean the same as Maxwell's corresponding Germans. They are plain enough, of course; but, as before mentioned, are open to objection. Finally, I found salvation in **Clarendons**, and introduced the use of the kind of type so called, I believe, for vectors (*Phil. Mag.*, August, 1886), and have found it thoroughly suitable. It is always in stock; it is very neat; it is perfectly legible (sometimes alarmingly so), and is suitable for use in formulæ along with other types, Roman or italic, as the case may be, contrasting and also harmonising well with them.

Sometimes block letters have been used; but it is sufficient merely to look at a mixed formula containing them to see that they are not quite suitable. I should mention here, however, that it is not the mere use of special types that converts scalar to vector algebra. For instance, engineers have often to deal with vector magnitudes in their calculations, but not (save exceptionally) in their vectorial signification. That is, it is merely their size that is in question, and when this is the case there is no particular reason why a special kind of type should be used, whether blocks or another sort.

In connection with Clarendon type, a remark may be made on a subject which is important to the community in general. I refer to the retrograde movement in typography which has been going on for the last 20 years or so. Many people, who possess fairly good and normal eyesight, find a difficulty in reading printed books without straining the eyes, and do not know the reason. They may think the print is too small, or that the light is not good, or that their eyes are not right. But the size of type *per se* has little to do with its legibility; a far more important factor is the style of type, especially as regards the fineness of the marks printed. The "old style," revived a generation since, and now largely in use, differs from the more legible "modern style" (of this page, for instance) in two respects. It has certain eccentricities of shape, which make it somewhat less easy to read; but, more importantly, the letters on the types are cut a good deal finer, which results in a pale impression, as if the ink were watery. This is the main cause of the strain upon the eyes, and the good light wanted. Even very small print is easy to read if it be bold and black, not thin and pale. It would be a public benefit if the retrograde step were reversed, and the revived old style, which threatens to drive out the modern style, discarded. Not that the latter is perfect. A still better style would be arrived at by thickening the fine lines in it, producing something intermediate between it and the Clarendon style (which last, of course, would be too much of a good thing). As everyone who has had to read MSS. knows, the most legible handwritings—irrespective of the proper formation of the letters—are those in which the writing-master's fine upstroke is discarded. Now it is the same in print. Thicken the fine lines, and the effect is magical.

§ 104. The tensor of a vector is its size, or magnitude apart from direction. Other important connected quantities are its three rectangular scalar components—the Cartesian components—which are the tensors of the three rectangular vector components. It is usual, in Cartesian work, to use three separate letters for these components, as F, G, H; or u, v, w; or ξ, η, ζ, &c. One objection to this practice is that when there s a large number of vectors the memory is strongly taxed to remember their proper constituents. Another is the prodigal waste of useful letters. One alphabet is soon exhausted, and others have to be drawn upon.

In my notation the same letter serves for the vector itself, and for its tensor and components. Thus, $\mathbf{E}$ denoting any vector, its tensor is E, and its components are E_1, E_2, E_3. Similarly, the tensor of $\mathbf{a}$ is a, and the components are a_1, a_2, a_3. A large stock of letters is thus set free for other use.

But a remark must be made concerning MS. work, as distinguished from printed work. In MS. work it is inconvenient to be at the trouble of writing two kinds of letters; ordinary letters will suffice for both scalars and vectors. Or the ordinary letters representing vectors may receive some conventional mark to vectorise them. But, presuming ordinary letters are written, something is required to distinguish between the vector and its tensor. This may be satisfied by calling E_0 the tensor of $\mathbf{E}$. Only when an investigation is to be written out for the printers is it necessary to bring in special letters, and this is most simply done by a conventional mark affixed to every (to be) vector. Compositors are very intelligent, read mathematics like winking, and carry out all instructions made by the author.

If a vector $\mathbf{a}$ be multiplied by a scalar x, the result, written $x\mathbf{a}$ or $\mathbf{a}x$, is a vector x times as big as $\mathbf{a}$, and having the same direction. Thus, if $\mathbf{a}_1$ be a unit vector parallel to $\mathbf{a}$ (or, more strictly, parallel to and concurrent with $\mathbf{a}$), of unit length, we have $\mathbf{a} = a\mathbf{a}_1$. It is sometimes useful to separately represent the direction and length of a vector, and the above is a convenient way of doing it without introducing new letters. This applies to any vector. But it need not be an absolute rule. For instance, the Cartesian co-ordinates x, y, z of a point may be retained. Thus, let $\mathbf{r}$ be the vector from the origin to any point, and let $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$ be unit vectors from the origin along the three rectangular axes. We shall then have

$$\mathbf{x} = x\mathbf{i}, \quad \mathbf{y} = y\mathbf{j}, \quad \mathbf{z} = z\mathbf{k}, \quad . \quad . \quad (1)$$

where $\mathbf{x}$ is the vector projection of $\mathbf{r}$ on the $\mathbf{i}$ axis, as we know by the elementary geometry of a rectangular parallelepiped or brick. Also, the direction-cosines of $\mathbf{r}$ are x/r, y/r, r/z, and

$$r^2 = x^2 + y^2 + z^2, \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

by Euclid I., 47.

§ 105. This brings us to vector addition. The vector $\mathbf{x}$ signifies translation through the distance x in the direction $\mathbf{i}$.

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If, now, after performing this operation, we carry out the operation indicated by **y**, viz., translation through the distance y in the direction **j**; and, lastly, carry out the operation **z**, or translation through the distance z in the **k** direction, we shall arrive at the end of the vector **r**. That is, starting from one corner of a brick, we may reach the opposite corner by three mutually perpendicular journeys along three edges of the brick. The final result is the same as if we went straight across from corner to corner, that is, by carrying out the operation indicated by the vector **r**. This equivalence is expressed by

$$\mathbf{r} = \mathbf{x} + \mathbf{y} + \mathbf{z}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Or, by (1),

$$\mathbf{r} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}. \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The meaning of addition of vectors in this example is simply the carrying out of the operations implied by the individual vectors added, the geometrical vector meaning a displacement in space, or translation from one point to another. The order of addition is indifferent, since there are six ways of going from one corner to the opposite one of a brick along its edges.

We see that any vector may be expressed as the sum of three mutually perpendicular vectors, viz., its vector projections on its axes. Furthermore, by the use of a skew parallelepiped instead of a brick we see that any vector may be expressed as the sum of three other vectors having any directions we please, provided they are independent, or not all in the same plane. For in the latter case the parallelepiped degenerates to a plane figure.

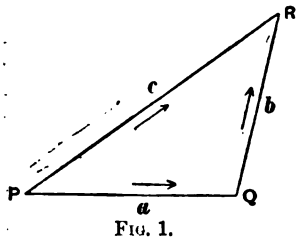

Fig. 1.

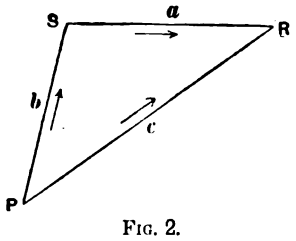

Fig. 2.

But it is perhaps best to explain vector addition in general without any reference to axes. Thus let **a** and **b** be vectors to be added, **a** meaning translation from P to Q in the first figure, or through an equal distance along any parallel line, as from S to R in the second figure, whilst **b** means translation from Q to R in the first figure, or through an equal distance along any parallel line, as from P to S in the second figure. In the first case, performing the operation **a** first, and then **b**, we go from P to R *viâ* Q; in the second case, with **b** first and then **a**, we go from P to R *viâ* S. The final result in either case is equivalent to direct translation from P to R, symbolised by the vector **c**. Thus,

$$\mathbf{c} = \mathbf{a} + \mathbf{b} = \mathbf{b} + \mathbf{a}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The above may be extended to any number of vectors. Or we may reason thus:—Let **A** be any given vector, translating, say, from P to Q. We need not go from P to Q direct, but may follow any one of an infinite number of paths, as for example,

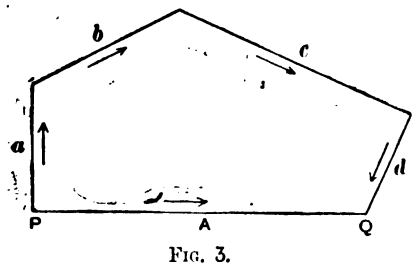

Fig. 3.

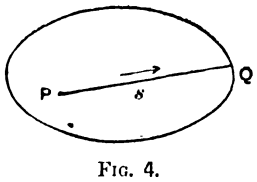

Fig. 4.

$\mathbf{a}+\mathbf{b}+\mathbf{c}+\mathbf{d}$ in the figure. The final result of the successive translations is always the same, viz., the direct translation **A**.

Or

$$\mathbf{A} = \mathbf{a} + \mathbf{b} + \mathbf{c} + \mathbf{d}. \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Thus any vector **A** may be split up into the sum of any number n of vectors, of which $n-1$ are perfectly arbitrary, for instance **a**, **b**, **c** in the figure. The remaining one **d** is, of course, not arbitrary. It is the vector required to complete the circuit of vectors.

The vectors need not be in one plane. Nor need the path followed consist of finite straight portions. It may be wholly or partly curved. The curved portions are then made up of infinitesimal vectors. Each curved portion may be replaced by the vector joining its terminals.

Since the original vector and the substituted vectors form a circuit, if the positive direction in the circuit be the same for all the vectors, we may express vector addition thus:—The sum of any number of vectors which make a circuit is zero. That is, $\Sigma\mathbf{a} = 0$, if **a** is the type of the vectors summed. For a curved circuit we shall have

$$\int d\mathbf{s} = 0, \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where $d\mathbf{s}$ is the vector element of the circuit. Here **s** itself may be taken to be the vector from *any* fixed point P to a point Q on the circuit. Then $d\mathbf{s}$ is the infinitesimal change in **s** made in an infinitesimal step along the circuit, that is, it is the vector element of the circuit itself.

In a vector equation every term is a vector, of course, however the individual terms may be made up, and every vector equation expresses the fact symbolised by (7), or by $\Sigma\mathbf{a} = 0$ when the vectors are finite. In the latter case, **a** may be also regarded as $\Delta\mathbf{s}$, the *finite* change in the vector **s** from any fixed origin produced by passing from beginning to end of the vector **a**.

The $-$ sign prefixed to a vector is the same as multiplication by -1, and its effect is simply to reverse the direction of translation. Or it may be regarded as reversing the tensor, without altering the direction: thus

$$-\mathbf{a} = -a\mathbf{a}_1 = a \times (-\mathbf{a}_1) = (-a) \times \mathbf{a}_1 \quad . \quad . \quad (8).$$

Thus, in any vector equation, for example

$$\mathbf{a} + \mathbf{b} + \mathbf{c} + \mathbf{d} + \mathbf{e} + \mathbf{f} = 0, \quad . \quad . \quad . \quad . \quad (9)$$

we may transfer any terms to the other side by prefixing the $-$ sign. Thus,

$$\mathbf{a} + \mathbf{b} + \mathbf{c} - = -\mathbf{d} - \mathbf{e} - \mathbf{f} = -(\mathbf{d} + \mathbf{e} + \mathbf{f}) \ldots \quad . \quad (10)$$

In the form (9) we express the fact that translation in a circuit is equivalent to no translation. In (10), however, we express the equivalence of two translations by different paths from one point to another.

If any trouble be experienced in seeing the necessary truth of (9) for a circuit in whatever order the addition be made, the matter may be clinched by means of **i**, **j**, **k**, the unit rectangular vectors; as we saw before, the resolution of vectors into rectangular component vectors depends only upon the properties of the right angled triangle. Thus split up the vectors **a**, **b**, **c** into components, we have

$$\left.\begin{aligned} \mathbf{a} &= \mathbf{i}\,a_1 + \mathbf{j}\,a_2 + \mathbf{k}\,a_3, \\ \mathbf{b} &= \mathbf{i}\,b_1 + \mathbf{j}\,b_2 + \mathbf{k}\,b_3, \\ \mathbf{c} &= \mathbf{i}\,c_1 + \mathbf{j}\,c_2 + \mathbf{k}\,c_3, \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Now add up. All vectors parallel to **i** add in scalar fashion, for there is no change of direction. Similarly for **j** and **k**; so we have

$$(\mathbf{a} + \mathbf{b} + \mathbf{c}) = \mathbf{i}\,(a_1 + b_1 + c_1) + \mathbf{j}\,(a_2 + b_2 + c_2) + \mathbf{k}\,(a_3 + b_3 + c_3).$$

Now the scalar additions may be done in any order we please. It follows that the same is true in vector addition. The addition and subtraction of vectors and transfer from one side of an equation to the other are thus done identically as in the algebra of scalars. Addition has, it is true, not the same meaning, but the vector meaning is not inconsistent with the scalar meaning, and, in fact, includes the latter as a particular case. There is never any conflict between $+$ put between vectors and $+$ put between scalars.

§ **106.** In the above we have referred entirely to the geometrical vector. But a very important step further can be made referring to physical vectors, a step which immediately does away with piles of ingeniously constructed and brain-wasting "demonstrations," especially compiled for the torturing of students and discouragement of learning. If a quantity be recognised to be a directed magnitude, it is, in its mathematical aspect, a vector, and is therefore subject to the same laws as *the* vector, or geometrical vector. So, just as we have the triangle, or parallelogram, or polygon of geometrical vectors, we must have the same property exemplified in the addition of all vectors, as velocity, acceleration, force, &c. This identity of

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treatment applies not only to the addition property, but to the multiplication and other properties to be later considered. We may symbolise a physical vector by a straight line of given length and direction.

It used to be thought necessary to give demonstrations of the parallelogram of forces, perhaps even before the student knew what force meant. I have some dim recollection of days spent in trying to make out Duchayla's proof, which was certainly elaborate and painstaking, though benumbing. Maxwell, in his treatise, elaborated a demonstration that electric currents compounded according to the vector law. But surely there is something of the vicious circle in such demonstrations. Is it not sufficient to recognise that a quantity is a vector, to know that it follows the laws of the geometrical vector, the addition property of which does not want demonstrating, but only pointing out, as in the polygon of vectors?

Although this is not the place for exercises and examples, yet it is worth while to point out that by means of the addition property of vectors a good deal of geometry can be simply done—better than by Euclid, a considerable part of whose 12 books consists of examples of how not to do it (especially Book V.). There is a Society for the Improvement of Geometrical Teaching. I have no knowledge of its work; but as to the need of improvement there can be no question whilst the reign of Euclid continues. My own idea of a useful course is to begin with arithmetic, and then, not Euclid, but algebra. Next, not Euclid, but practical geometry, solid as well as plane; not demonstrations, but to make acquaintance. Then, not Euclid, but elementary vectors, conjoined with algebra, and applied to geometry. Addition first; then the scalar product. This covers a large ground. When more advanced, bring in the vector product. Elementary calculus should go on simultaneously, and come into the vector algebraic geometry after a bit. Euclid might be an extra course for learned men, like Homer. But Euclid for children is barbarous.

(To be continued.)

THE DISSIPATION OF ENERGY THROUGH REVERSALS OF MAGNETISM IN THE CORE OF A TRANSFORMER.

At a meeting of the Cavendish Physical Society, Cambridge, on Tuesday, Prof. Ewing communicated the preliminary results of experiments on this subject, which had been made by him in conjunction with Miss H. G. Klaassen. The particular object of the inquiry was to test whether the reputed reduction of loss through hysteresis when a transformer is loaded actually takes place. A reduction of loss when the transformer was loaded had appeared to take place in trials by Prof. Ryan, Mr. Mordey, and Prof. Ayrton; but the results were, perhaps, scarcely decisive, for in most of these experiments the loss was determined not directly, but as the difference between two relatively great quantities. The method of measurement now used was a direct one, described by Prof. Ewing in *The Electrician* of October 9th. Two precisely similar transformers were wound, the core consisting in each case of a ring of insulated iron wire, over which there were two equal primaries and two equal secondaries. But the primaries of one transformer were wound so as to oppose each other, and the secondaries of the same transformer were also wound so as to oppose each other. The result was that that transformer was magnetically inactive whatever current was passed through its primary or its secondary. The two transformers were connected in series; the same alternating magnetising current traversed the primaries of both, but produced no magnetic effect on the inactive one. And when the secondary circuit was closed, the inactive secondary was included in series with the active secondary. Hence the Joule effects, that is to say the amounts of heat developed on account of the resistance of the primary and secondary coils, were identical in both. The active transformer tended to become hot faster than the other, because of hysteresis and Foucault currents in the core; but the rate of heating of the inactive core was made as great as that of the active one by passing a current of regulated strength through its iron wire. Equality of temperature was maintained in this way, the equality being tested by thermo-electric junctions imbedded in each core. From first to last it was a *nul* method, and experiments showed it to be capable of giving consistent and satisfactory results. If the balancing current was wrong by five per cent., a few seconds of steady working sufficed to produce a difference of temperature sufficient to indicate whether the current should be adjusted to a stronger or weaker value. The strength of this current served, of course, to measure the power which was being wasted in the core of the active transformer. To secure that the magnetic induction **B** should have the same value throughout a series of tests under various loads, the device was adopted of winding on the transformer a short "tertiary," or special induction coil, which was connected to a hot-wire voltmeter of very simple construction. A liquid rheostat in the primary circuit allowed the primary current to be regulated so that the limits of magnetisation remained unchanged when the secondary current was varied. The alternating primary currents were derived from a larger transformer, which, in its turn, was excited by a commutated current from a storage battery. The frequency of the reversals was maintained constant by the aid of a tuning fork, with which the hum of the exciting transformer was kept in unison. The purpose in using an exciting transformer was to secure more nearly sinusoidal currents than would have been given had the commutator been directly connected with the transformer under test.

After adjusting the balancing current in the iron wire of the inactive transformer while the secondary circuit was open, so that the rate of heating by that current in the inactive core was just equal to the rate of heating through hysteresis and Foucault currents in the active core, the secondary circuit was closed through a resistance small enough to load the transformer heavily, and the primary current was increased to bring **B**, as tested by the "tertiary" volts, to the same value as before.

No difference could be detected in the amount of balancing current required to maintain the equilibrium of temperature. In other words, the loss through hysteresis and Foucault currents in the iron core went on at just the same rate whether the secondary was closed or not, even when the load on the secondary was allowed to be considerably greater than would correspond with the conditions of practice in commercial transformers.

The experiment was varied by transposing the active and inactive coils; by adjusting first when the load was on, and then taking the load off; by using various amounts of resistance in the secondary circuit; by using various frequencies, ranging from about 100 to 130 cycles per second; by working with several different degrees of maximum induction, **B**, ranging from about 6,000 to 12,000 C.-G.-S. In no case did a difference in the core loss show itself when the load was put on or taken off.

The experiments seem decisive of the point at issue, at least to this extent, that if an alteration of as much as 5 per cent. in the strength of the balancing current had been necessary it would have been detected. In point of fact, no alteration was found to be necessary.

The experiments are being continued with the object of making absolute measurements of the loss through hysteresis under various frequencies and various intensities of induction, and of comparing the loss in reversals under the conditions of a transformer with the loss that is represented by $\int \mathbf{H}\, d\mathbf{I}$ in slowly performed magnetic cycles.

Telegraphic Communication with the Transvaal.—At last measures are being taken, says *South Africa*, for the purpose of bringing the Transvaal in direct communication with Delagoa Bay by wire. There is a distance of under a hundred miles to be spanned by the wire, when direct communication between Pretoria and Delagoa Bay, through Barberton, will be attained. This is a convenience long looked forward to, and when attained will be a great boon to the State, and to these fields especially. As it is now, we have to send a wire to Delagoa Bay, *vid* Natal, and so have to pay cable tariff.

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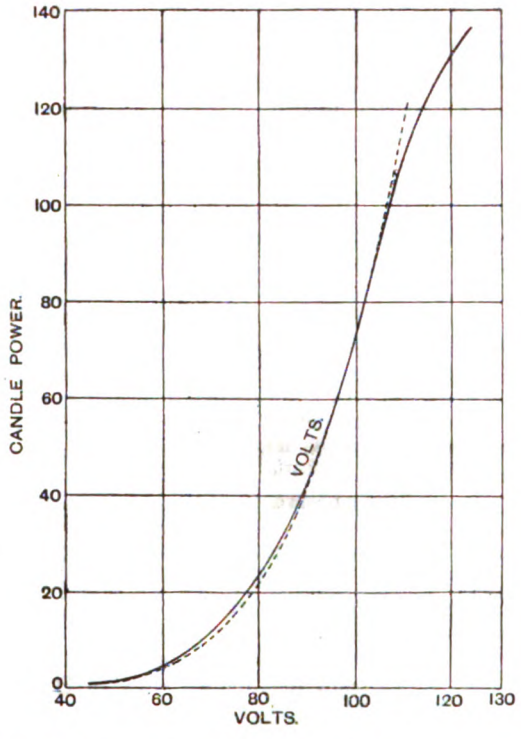
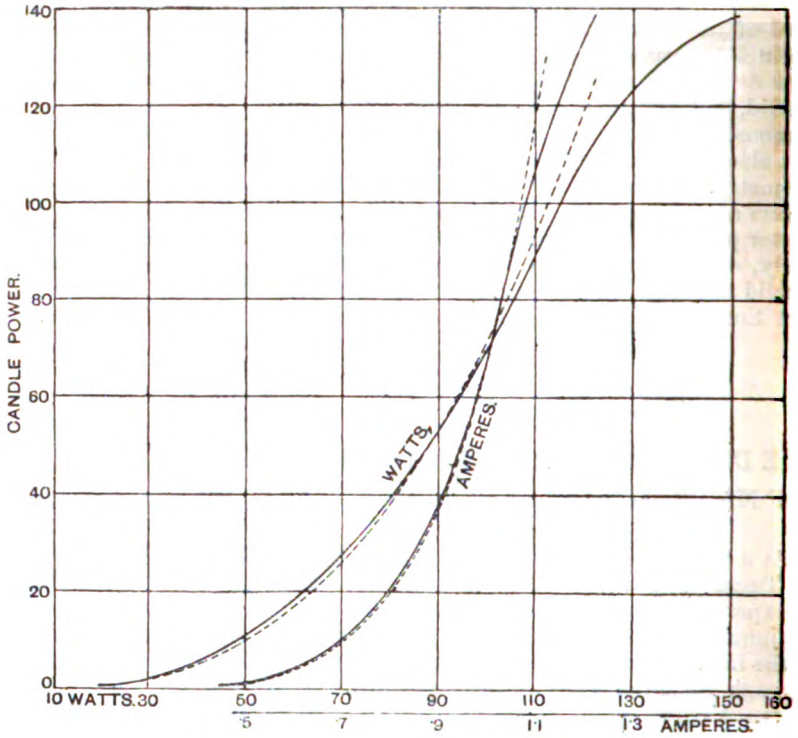
ON THE CANDLE-POWER OF INCANDESCENT LAMPS AS RELATED TO CURRENT, VOLTAGE, AND ENERGY CONSUMED.*

BY LOUIS A. FERGUSON AND DAVID A. CENTER.

The observations described in the present Paper have for their object the study of the relation between the illuminating power of various incandescent lamps now in use, and the current, potential, and expenditure of energy used in operating them. The observations were made in the spring of 1888, but various circumstances have delayed their publication till the present time.

The subject has already been considered by several persons, and it has appeared that for such lamps as have been tested the candle-power is approximately proportional to the cube of the current, and to the fifth power of the potential difference between the terminals of the lamps. It seemed to us, however, that it was desirable to carry out a series of tests with more recent lamps, and with a greater variety of them than had been employed in former experiments upon the subject. It was also thought that a consideration of the relation between the candle-power and the potential difference between the terminals of the lamp (or electrical pressure) would be useful.





We considered it best, on the whole, to express our results in the form of a simple exponential equation of the form $y = a x^n$, as has been customary, notwithstanding the fact that, as Götz has shown,† at least for the relation between candle-power and energy expended, the results of experiments are more accurately expressed by an equation of the form $y = a x + b x^n$.

The greater simplicity of the common formula has decided advantages in its practical application which go far to make up for the somewhat diminished accuracy at extreme values of the candle-power, while within quite wide ranges it is amply exact for all practical purposes.

There were tested in all twenty-one lamps, including those made by the Edison, United States, Thomson-Houston, and Westinghouse Companies, having in every case a good normal filament. The photometric measurements were made with a Bunsen photometer. The lamp to be tested was placed in the circuit of an Edison or Westinghouse direct-current dynamo, from either of which machines an electromotive force of 110 volts could be obtained, and by coupling the two machines in series the lamp could be put into a circuit having a potential of 220 volts.

In the same circuit with the lamp to be tested was placed a Thomson graded current galvanometer, by which the current could be measured with ease within 1 per cent. The difference of potential at the terminals of the lamp was measured by a Thomson potential galvanometer, whose readings also could be depended upon to at least 1 per cent. The product obtained by multiplying the current in amperes by the difference of potential at the terminals of the lamp in volts, gave the rate in watts at which energy was consumed in the lamp at any given time.

The necessary variation in the current and electromotive force in the working circuit was accomplished by means of a set of six Edison lamps placed in the circuit, with connections between the lamps so arranged that any number of lamps could be thrown out of circuit at a time, or two or three thrown in parallel with each other, thus giving a wide range of variation of resistance. For smaller variations a set of German silver resistance coils was constructed and arranged so that changes from one-fourth of an ohm up to 75 ohms could readily be secured. A Methven slit was used as a standard of light.

In all cases, except with those of the United States Company, the lamps were placed so that the plane of the filament was at right angles to the plane of the bar. They were kept in this position throughout the test. The United States lamps were placed so that the plane of the filament made an angle of 45 degrees with the bar.

The lamps were first started at about two-tenths of a candle-power, the resistance in circuit then being decreased until a suitable reading was obtained on the photometer, when a series of twelve or more readings was made of the candle-power by one observer, while the other, as often as possible during the interval, read the current in the circuit and the potential at the terminals of the lamp. The resistance was again changed and new measurements taken of the candle-power, current, and potential, this mode of procedure being continued in most cases until the filament gave way. In some cases it was not broken in the first test, and a second run on the lamps was made. In every such instance it was found that the curve of relation ran lower than in the first test, showing that the effect upon the lamp was to decrease its efficiency, more energy per candle being consumed in the second run. It was also found, in a few instances where it was impossible to finish a test of the lamp on the same day that it was begun, that on resuming the test it required more energy per candle than on the first day, until after some fifteen minutes had elapsed, when the original values were again obtained.

As a matter of some interest, several tests were made upon some of the Edison lamps to find out, if possible, about how much energy must be expended in such a lamp in order that the first appearance of light might be distinguished with the naked eye in a positively dark room. It was also thought to be of interest to know the colour of the light in this case. Measurements were made of the current and potential, and it was found that the mean value of the energy expended when the light first became visible to the most sensitive observer was about 0·74 watt. The colour of the light emitted by the filament was in all cases of an ashy grey.

Nearly every style of lamp seemed to have one particular place at which the filament gave way. The Edison filament, in every

* Abstract of a Paper read at a meeting of the American Academy of Arts and Sciences. (From *The Technology Quarterly.*

† *Centralblatt für Elektrotechnik*, Vol. V., p 720.

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instance but one, broke at from one-eighth to one-half an inch above the platinum joint on the right-hand side, looking at the labelled side of the globe. The circuit wires were removed from the lamp-socket before this fact was noted, so that we are unable to state whether this was the positive or negative side. The filament of the Weston lamps always broke at about one inch from the top, while that of the Thomson-Houston lamps broke at the top. One of the Westinghouse lamps broke at about one-eighth of an inch above the middle point of the right-hand side of the filament, looking at the labelled side of the globe; another broke at about one-eighth of an inch above the joint on the same side. In nearly all the lamps tested the joints were noticed to be very black, due to deposition of carbon by the Crookes' effect.

A series of curves was constructed, showing graphically the relations between the candle-power and the current, potential, and energy expended, and equations of the form $y=ax^n$ satisfying the observed values of the variables were determined by the method of least squares for the various lamps in the case of the current and energy determinations. In these the candle-power is denoted by y and the other variable by x. From these equations others, giving the relation between the potential and candle-power, were calculated. This calculation, together with other aid in the preparation of some of our tables, we owe to the kindness of Mr. Edward Collins, Jr., of the Rogers Laboratory.

We had observed that in nearly all cases as the lamp approached the breaking-point the curve ceased to run up with its usual steepness, the candle-power falling off very rapidly. In the calculations of the equation for each lamp, all observations above this point at which the curve fell off were neglected as being of no value for our determinations. This we felt justified in doing, since our object was to deduce an equation which would show the relation between the candle-power and current, or other variable, as long as the former increases regularly with the latter. We calculated the equation for each separate lamp, and from these deduced, by the usual method, a general equation applying to each particular kind of lamp. Below are given a few specimens of the individual equations, as well as the general equations calculated from them.

The Edison lamps used were of the "new style," 3·1 watts per candle-power, and the Weston lamps were the "tamadine lamps."

EDISON, 16 c.p., 110 volts.

(A) $y=500\ x^{5\cdot3}$

(B) $y=540\ x^{5\cdot0}$

GENERAL EQUATION $v=520\ x^{5\cdot1}$

EDISON, 10 c.p., 110 volts.

(C) $y=490\ x^{4\cdot7}$

THOMSON-HOUSTON, 16 c.p., 75 volts.

(H) $y=0\cdot000157\ x^{2\cdot8}$

(J) $y=0\cdot000153\ x^{2\cdot8}$

GENERAL EQUATION $y=0\cdot000155\ x^{2\cdot8}$

The following equations showing the relation between the candle-power and potential difference between the lamp terminals, as already stated, were calculated from the preceding equations, except in the case of (F) (G) (P), which were obtained directly from the observed results.

EDISON, 16 c.p., 110 volts.

(A) $y=0\cdot000000000000021\ x^{7\cdot3}$

(B) $y=0\cdot000000000000151\ x^{6\cdot8}$

GENERAL EQUATION $y=0\cdot0000000000000082\ x^{7\cdot4}$

EDISON, 10 c.p., 110 volts.

(C) $y=0\cdot0000000000000082\ x^{6\cdot2}$

THOMSON-HOUSTON, 16 c.p., 75 volts.

(H) $y=71\cdot5\ x^{6\cdot2}$

(J) $y=68\cdot9\ x^{6\cdot6}$

GENERAL EQUATION $y=74\ x^{6\cdot9}$

In like manner were obtained the relations between the candle-power and the energy expended, which are as follows:—

EDISON, 16 c.p., 110 volts.

(A) $y=0\cdot000065\ x^{3\cdot1}$

(B) $y=0\cdot000131\ x^{2\cdot9}$

GENERAL EQUATION $y=0\cdot000098\ x^3$

EDISON, 10 c.p., 110 volts.

(C) $y=0\cdot000087\ x^3$

THOMSON-HOUSTON, 16 c.p., 75 volts.

(H) $y=0\cdot0000000037\ x^{5\cdot1}$

(J) $y=0\cdot0000000003\ x^{5\cdot7}$

GENERAL EQUATION $y=0\cdot0000000011\ x^{5\cdot4}$

Although our general equations would be much enhanced in value if we could have employed a larger number of each kind of lamp in our investigations, there are, nevertheless, certain facts that are clearly evident from our results. The lamps at present used, like the earlier ones, increase in candle-power about as the fifth power of the current employed, and as the cube of the energy expended. It will also be seen that the candle-power increases about as the sixth power of the potential difference between the terminals of the lamp. The average value of the exponent of x, the candle-power for the current equations, is 5·3; for the energy equations, 2·9; and for the potential difference equations, 6·4.

To illustrate the agreement of the exponential equations with the observed relations between candle-power and current, potential difference, and energy expended, the curves shown in Figs. 1, 2, 3, were plotted for the Thomson-Houston 16 c.p., 75-volt lamp. The equations used were the individual ones for that special lamp.

BOOKS, &c., RECEIVED.

"Arithmetic of Electricity." By T. O'Connor Sloane, Ph.D. (London: E. and F. N. Spon.)

"St. Pancras Electrical Exhibition. Addresses."

"Catalogue of the International Electric Company."

"Le Gaz et ses Applications." Par E. de Mont-Serrat et E. Brisac. Bibliothèque des Connaissances utiles. (Paris: J. B. Baillière et Fils.) Price 4 francs.

"The Mechanical Engineer's Pocket-Book." By D. Kinnear Clark, M.Inst.C.E. (London: Crosby Lockwood and Son.)

"Glasgow and West of Scotland Technical College Calendar for 1891-92."

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, December 4th. (To-day.)

INSTITUTION OF CIVIL ENGINEERS.

2 p.m. Students' visit to inspect the new Refrigerating Plant at Nelson's Wharf, Lambeth.

PHYSICAL SOCIETY.

5 p.m. Papers to be read:—(1.) "On a Permanent Magnetic Field." By W. Hibbert. (2.) "Note on the Production of Rotatory Currents." By Prof. Ayrton, F.R.S.

OLD STUDENTS' ASSOCIATION.

7:30 p.m. Smoking Concert at Masons' Hall Tavern

MONDAY, December 7th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

TUESDAY, December 8th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read with a view to discussion:—"The Sale of Water by Meter in Berlin." By Henry Gill, M. Inst. C.E.

WEDNESDAY, December 9th.

SOCIETY OF ARTS.

8 p.m. Ordinary meeting. Paper to be read:—"The World's Columbian Exposition at Chicago in 1893." By James Dredge.

THURSDAY, December 10th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Annual General Meeting. Election of Council and Officers, after which a Paper will be read:—"On the Specification of Insulated Conductors for Electric Lighting and other purposes." By W. H. Preece, F.R.S.

FRIDAY, December 11th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read:—"Meters for Recording the Consumption of Electrical Energy." By C. H. Wordingham, A.K.C., Stud. Inst. C.E.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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SMALL ADVERTISEMENTS *accepted up to 4 p.m. Thursday.*

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THE MICROPHONE IN AMERICA.

Although it seems but yesterday that Prof. HUGHES made public his curious discovery of the microphone, the announcement of a new microphonic patent comes upon us as a surprise. Our wonder is not lessened perhaps, but rather increased, when we turn back to the records and find that nearly fourteen years have elapsed since that ingenious device came to light in England, and almost as long since it was born again in New York. In the latter place it was christened an original invention and patented straight away, although its English parent had made a present of it to the world at large. The "new" world, however, having accepted it from other hands, has had to pay for it pretty stiffly, and with results following which are creating astonishment even in the land where patents are commonly worked in defiance of public opinion, and disregard of public rights. We are not sure that the old world, or England in particular, has profited much by Prof. HUGHES' magnanimity; for so soon as the microphone was adapted to the purposes of a telephone transmitter it became patentable here as elsewhere, though the microphone as such could not. But, all the same, we are not likely to grant it a fresh lease of life in that or any other guise; and on this we may congratulate ourselves, as well as commiserate our American brethren, who have just now learnt with dismay that another long patent has

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been secured for a form of microphone so comprehensive in its claims that telephonic transmission will be almost impossible without its assistance, and its monopoly extended just as if the telephone patent were itself a new invention.

How this has been brought about is rather a long and not very edifying story. Our readers have heard of the Berliner microphone, or telephone transmitter, and by this time have probably forgotten what it was. In reality it was a metallic diaphragm resting on a metal point, both included in a battery circuit; and the inventor distinctly states that the two points must be of metal, and in constant contact, with other conditions equally removed from the microphone principle as known to us more than thirteen years ago. But the claims as set forth, as claims usually do, included a good deal more than the inventor had invented, and one of them runs as follows:—

1. The method of producing in a circuit electrical undulations similar in form to sound waves, by causing the sound waves to vary the pressure between electrodes in constant contact, so as to strengthen and weaken the contact and thereby increase and diminish the resistance of the circuit substantially as described.

These "electrodes" would appear to cover the carbons commonly in use; and the American Courts have ruled, probably on that account chiefly, that the Berliner patent dominates the Edison and other patents; and have allowed it to be issued because it was applied for earlier than any of the rest. But why, the ingenious reader will exclaim, why was it not issued before now if applied for so long ago? We shall have to go as far as New York to find a p'liceman able to answer that question. And, indeed, that kind of functionary would seem to be the right person to apply to; for if what the American technical journals and our New York correspondent tell us is correct, the course of conduct which has enabled this embryo patent to be uncorked and deposited on the Patent Office table as a real live invention, has been of a sort that calls for the stern interposition of the law. Of the leading features of the case there can be no doubt at all. The Edison patent—a subsequent one to that of the Berliner—being secured, and being, we may add, more workable, it was proceeded with. Then there came a godsend in the Drawbaugh litigation—a mere bogus suit, as everybody now believes, which kept the other patents in legal abeyance for eleven long years, although one of them was being exploited most profitably all the while. Both the Berliner and the Edison patents had fallen into one set of hands, with the result, if not the intention, that if the Edison was beaten at law by a superior rival, the Berliner device would be played as a trump card.

This at least is certain. But, as events have recently shown, the retention of the Berliner patent in a condition of suspended animation served the further purpose of putting new life into the Edison instrument, though the Edison patent might be extinguished. We do not understand the law and process of "interference" in the United States Patent Office; but it would seem that by judiciously manipulating the "interferences" provided by the Drawbaugh and Edison and the Berliner and Edison suits, the validity of the latter has been kept undecided until now. That being so, for all practical—or rather for all judicial—purposes, there has been no Edison patent any more than there has been a Drawbaugh patent; and the Berliner patent—poor injured innocent!—is now allowed to claim its rights, of which it has been deprived ever since June, 1877. The Berliner patent dates from now, therefore; and unless anyone powerful enough to interpose successfully steps in, the microphone transmitter will run another 17 years of undisputed, and, we may venture to add, undeserved monopoly. It is as if one had appropriated a wrong umbrella, and after wearing it out taken it back again, getting a new one in its place. You cannot do that in polite society; but you can in the New York Patent Office.

Our information from the locality indicates a strong feeling of indignation at the whole proceeding, and there is talk of invoking the aid of the Legislature to put an end to collusive and injurious "interferences." We sincerely wish success to any endeavours of that kind. But we are not very sanguine as to any useful action being possible as regards the particular case in point. The whole business appears unimpeachable in point of law; and the actors are possessed of great riches to defend what the law has awarded. The investing public in the States are of that opinion, too, for the price of American "Bell" shares—the Bell Company being the owners of both patents—is reported to have risen from 185 to 210 within the last fortnight in consequence of the new patent. It is really a sad, not to say scandalous, business; and we can say this with all the more sincerity because we are not profoundly grieved on our own account. We at least may enjoy free trade in microphone transmitters, none the less for its being protected in America. Perhaps before long we may be manufacturing microphones for exportation to that much be-tariffed country, for the use of the Bell Company itself; and if McKinley will not let us, so much the worse for McKinley and all his works.

THE CHICAGO EXHIBITION EXECUTIVE AND THE ROYAL COMMISSION.

As will be seen by an extract in our "Notes" columns, the action of the Society of Arts in proposing to levy a tax for floor-space upon English firms who are bold enough to exhibit at Chicago in 1893 has, not unnaturally, caused considerable chagrin in that progressive city. The English Commissioners, say the Exhibition officials, were given 250,000 square feet for nothing, and promised more; and here they are endangering the success of the Show by taxing English exhibitors. The disease, however, admits of a simple remedy. We do not suppose that our diplomatic relations with the United States would be very seriously strained if the Chicago Exhibition Executive were to throw over the Royal Commission altogether, and negotiate directly with prospective exhibitors. Since our American friends are so strangely anxious to give their "Fair" a flavour of internationality, why not pay for the fad? In the electrical branch, for example, we feel sure that the designers of the Manchester-square and Kensington Court stations would be ready on receipt of an adequate subsidy to reproduce these typical English central stations on the shores of Lake Michigan; and no doubt one of Mr. Ferranti's 10,000 H.P. abnormities could be loaned from the London Electric Supply Corporation for a trifling consideration. It is a mere question of dollars.

Seriously speaking, however, it seems to us that if, as some assert, it is desirable as a matter of broad policy that Great Britain should be well represented at Chicago, it follows that the Government—the conditions being manifestly so adverse—should not merely be content to refrain from throwing obstacles in the path of English exhibitors, but should actively encourage them. The hostile tariff and the distance are a sufficient discouragement, without the superaddition of a tax of from 2s. 6d. to 5s. per square foot of floor space. It is the meagre Government grant of £25,000 which necessitates this charge; and if it be good policy for us to exhibit at all, it is worth while to substantially increase the sum in order to avoid this obnoxious tax.

By all means let Great Britain be well "represented" at Chicago. We understand that it is proposed to build "an

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attractive English manor-house" on the Lake front; the Eddystone Lighthouse from the late Naval Exhibition is to be re-erected; and it is said that the model of the "Victory" and a canvas reproduction of the Tower of London are to accompany it. To these might be added a mile or so of good wooden pavement and a few first-rate hansoms. With all this and more of the kind we cordially sympathise, if the expense be not borne by the exhibitor. In the early days of Exhibitions the exhibitor doubtless had his *quid pro quo* for any money expended; and such may still occasionally be the case. But, generally speaking, as things are now it is the promoter rather than the exhibitor who should bear the brunt of the expense, since it is the former and not the latter who reaps the golden harvest; and the relative position of the two parties is in no way altered if the promoter happens to be a great nation or a big city, and the exhibitor an unfortunate foreigner relentlessly harassed by cent. per cent. *ad valorem* duties. Moreover, a little consideration shows us that the exhibitor is a necessary antecedent to the Exhibition. Trade can get along very well now without annual, biennial, triennial, or even decennial Exhibitions; but where would these Exhibitions be without the support of the trade? The question of commercial Exhibitions of manufactures is in short an altogether different one, and we do not propose to reopen it again just at present; but will content ourselves with observing that if money must be spent it would be more profitably devoted to sending round a smart bagman to interview the buyers, according to the favourite American custom, than in displaying machinery to be stared at by mere sightseers, or to be inquisitively scrutinised by rival makers.

REVIEWS.

Testing of Insulated Wires and Cables. By HERBERT LAWS WEBB. (New York: D. Van Nostrand Company.)

This volume contains a series of articles which originally appeared in *The Electrical Engineer*, U.S., and deals solely with the well-recognised methods of determining the insulation resistance, conductor resistance, and electrostatic capacity of submarine telegraph and telephone cables. No doubt it is always difficult for an author to estimate what is the stage of knowledge that his readers have reached. Here the author evidently assumes that those he addresses are familiar with Ohm's and other elementary laws relating to electricity. The book is one of small pretensions, but to those who are making their first attempts to carry out these tests many practical hints are given as to the method of making them and as to the management of the instruments they will have to deal with.

It is impossible in a work of this size to mention all the various methods in practice for arriving at the insulation, conductivity, and capacity of cables; so the author confines his remarks to the direct deflection test for obtaining the insulation resistance, the Wheatstone Bridge for taking the conductor resistance, and the discharge method by comparison with a known capacity for determining the electrostatic capacity of insulated wires. No mention is made of the potential method for comparing resistances, or of the use of Sir W. Thomson's slides, which are, very late in the day, becoming well known and more frequently used than any other means for comparing and determining the capacity of cables.

On page 59 the author in his description of the manner of finding the "constant" of the galvanometer employed omits to include both the battery resistance and the combined resistance of the galvanometer and shunt in the amount of resistance in circuit, which is usually done. We find also stated on page 69 that if, when testing cables, sudden kicks are observed, "they may be taken as an almost sure indication that the wire or cable has an incipient fault." This inference is not necessarily correct, as the same effects are more frequently the result of defective battery or bad contacts.

The diagrams are simple and easily understood; the illustrations, on the other hand, have a want of clearness which does not recommend the process employed for their production, especially so where good definition is necessary.

The Elements of Dynamic Electricity and Magnetism. By PHILIP ATKINSON. (London: Crosby Lockwood and Son. 1891.)

But for one or two slips of a practical character this is a very fair elementary handbook, but it contains nothing that has not been better written elsewhere. No originality is aimed at, and the apparatus described is chiefly American. In discussing batteries the author remarks in italics that "the practical rule is to *make the internal resistance of the battery equal to the external resistance to be overcome.*" We were quite prepared, after this, to find that it recorded that the efficiency of a motor cannot be more than 50 per cent., but did not discover it; though an equally common and old-fashioned error appears in a section on magnetic lag, which, curiously enough, comes immediately after a reproduction of S. P. Thompson's diagram explaining the true theory of the lead of the brushes by armature reaction.

Arithmetical Physics. Book E. Part II.A. By C. J. WOODWARD, Municipal Technical School, Birmingham. (London: Simpkin, Marshall, Hamilton, Kent, and Co. 1891.)

About one-half of this book is composed of examination questions selected from the papers of the Science and Art Department. Two-thirds or more of the remainder consist of questions which assume that the student has burdened his memory with electro-chemical equivalents, &c., and which ignore the corrections which have to be made in practice. The following is an example:—"A battery of 6 cells gives a current of 2 amperes. Required the weight of zinc in grammes consumed in each cell of the battery per hour." The remainder of the book consists of "lessons" of a very feeble character.

The Wire and the Wave. By J. MUNRO. (London: The Religious Tract Society.)

This is a story for boys, and contains an interesting account of cable work, mixed up with more or less well-known cable stories, adventures, and love-making. The story, says the author in the preface, "is founded on this attractive mode of life, which combines the practice of electrical science with the delights of travel and adventure." This is all very well, but is it right to lead boys to suppose that this is a fair description of this "mode of life"?

Condensed Mechanics. By W. G. CRAWFORD HUGHES. (London: Crosby Lockwood and Son. 1891.)

This is a cram book, pretending to give formulæ, rules, tables, &c., for the use of engineering students, but really intended to enable them to pass certain examinations. The process of condensation seems to consist in the omission of descriptive or explanatory matter. The bulk of the book is occupied by half worked-out examples, without any hints as to the reasons.

Electricity and its Recent Applications. By EDWARD TREVERT. (Lynn, Mass.: Bubier Publishing Company. London: Gay and Bird. 1891.)

A collection of descriptions of electrical apparatus and machinery has been made by the author from technical journals, and these have been interspersed with directions to amateurs for constructing motors, &c. There is little coherence about the book, and the details are not so clearly given as most amateurs would wish.

Kalender für Electrotechniker. F. UPPENBORN. Ninth year, 1892. (Munich and Leipzic: R. Oldenburg.)

This excellent annual maintains its high character. It is full of useful tables, formulæ, and memoranda. No allusion is made to the *drehstrom* system, and too little attention is given to ordinary commercial measuring instruments. We have no book of the kind in the English language.

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THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 35.*)

§ 32. **Magnetic Force due to an Element.**—From what has been said above it will readily be suspected that the magnetic force due to an element of a current is really indeterminate. We are, however, able to state a law for the magnetic force due to an element which, when all the elements of a closed circuit are taken account of, will give an absolutely correct result. Suppose now that the magnetic induction is produced by a single pole of strength, m, placed at a distance, r, from the element, ds, of the current. Let the angle between r and the direction of the element of the current be θ. The value of the magnetic induction at ds is $\mathsf{B} = m/r^2$, and its direction is along r. Hence, according to the principles enunciated in the last paragraph, the force experienced by ds is $\mathsf{B}ids\sin\theta$ or $mids\sin\theta/r^2$. If the element of current and the pole are placed as in Fig. 34, both ds and m being in the plane of the paper, then it easily follows from the rule given in § 31 that the force experienced by ds is perpendicular to the paper and towards the reader. But by the equality of Action and Reaction the action of the element upon the pole must be an equal and opposite force *applied at* ds (not at m).

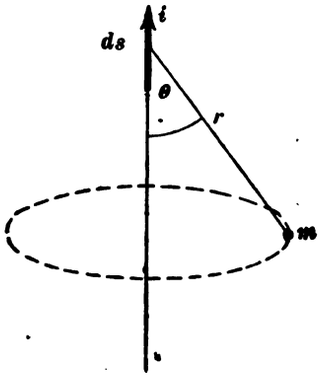

FIG. 34.

Without altering the system of forces in any way we can apply at m a pair of equal and opposite forces at right angles to the paper. By taking the one of these which points towards the reader in conjunction with the original force at ds, we see that the action is equivalent to a force $mids\sin\theta/r^2$ *applied at* m in the direction away from the reader, together with the couple produced by the pair of forces $mids\sin\theta/r^2$ applied to the ends of the radius r. The moment of the couple is therefore $mids\sin\theta/r$. Its axis (see § 6) is in the plane of r and ds at right angles to r, and points towards the direction *from* which the current is proceeding. Let the angle subtended by ds at m be $d\psi$, then it is very easily seen that $r\,d\psi = ds\sin\theta$, so that $d\psi = ds\sin\theta/r$.

Thus the moment of the couple is $mid\psi$ and its axis is in the plane of the angle $d\psi$. Now let a straight line, one of whose ends is fixed at the pole m, travel round the *closed* circuit of which ds forms part, thus tracing out a cone. About m as centre describe a sphere of radius im cutting the cone in a *closed* curve. This curve is clearly everywhere at right angles to the generating lines of the cone. The length of this curve intercepted by the two radii from m to the extremities of ds is $mid\psi$, and the direction of this intercept is at right angles to r. Hence the intercept represents in direction and magnitude the couple due to the element ds. Taking account of all the elements the couples due to them will be represented in direction and magnitude by the corresponding elements of the auxiliary curve. Since this curve is *closed*, the resultant couple is zero, and the action of the whole circuit upon m reduces to a single force applied *at* m, being the resultant of the set of forces similar to $mids\sin\theta/r^2$ applied *at* m. Hence, as long as we only apply our calculations to closed circuits, we may consider the element ids as producing a force $mids\sin\theta/r^2$ at m at right angles to the plane of r and ds. Or we may say that at a point defined by r and θ the element ids produces a magnetic force equal to $ids\sin\theta/r^2$.

It is clear that exactly the same indeterminateness enters into the specification of the magnetic field produced by an element of a current as in the case of the action of a magnetic field upon an element. But so long as we deal only with closed circuits we can calculate the magnetic field quite correctly from the expression $ids\sin\theta/r^2$. This proposition can be proved directly as follows: Give the pole m a small displacement x *in the direction of* the resultant magnetic force H due to the closed current. The work spent upon m during the motion is $m\mathsf{H}x$ ergs. We can also calculate the work spent from the expression $m.i.$ (change of solid angle subtended by circuit), see §§ 19, 20 and 30. The change of solid angle will be the same as if the whole circuit had been given a pure translation through a distance x, the pole meanwhile remaining stationary. When the element ds moves over the distance x it will sweep out a small area; we have to find the solid angle subtended by this area at m. Let θ be the angle between ds and r, ϕ the angle between the direction of x and the normal to the plane of r and ds. The projection of x upon this normal is $x\cos\phi$, so that the projection of the area swept out by ds upon the plane through ds and the normal just mentioned is $ds.\cos\phi$. The angle between this last plane and r is θ, so that the solid angle subtended at m is $ds.x\cos\phi\sin\theta/r^2$. The whole work extended during the motion is therefore $mix\int\frac{\cos\phi\sin\theta\,ds}{r^2}$ ergs, the integration extending all round the closed circuit. Hence $\mathsf{H} = i\int\frac{\cos\phi\sin\theta\,ds}{r^2}$. If we had attributed to each element a magnetic force $ids\sin\theta/r^2$ at right angles to the plane of r and ds, the resolved part of this, in the direction of x, and therefore also in the direction of H, would have been $\cos\phi.ids\sin\theta/r^2$. Thus the resultant magnetic force would have had the value $i\int\frac{\cos\phi\sin\theta\,ds}{r^2}$, the same result as before.

The complete investigation of the possible laws of action of an element (of which the law, represented by $ids\sin\theta/r^2$, is only one) is difficult and unsuited to the present series of articles. But I hope that I have said enough to indicate the class of difficulties which arise when we attempt to resolve a current into "elements."

§ 33. **Circular Conductor.**—In § 26 we found the magnetic force due to a circular coil at any point on its axis, by finding the differential coefficient of the solid angle subtended by the coil. We will now investigate the same subject by the help of the formula we have just obtained. Let a be the radius of the coil, x the distance from the centre of the coil of the point P on the axis at which the magnetic force is to be found.

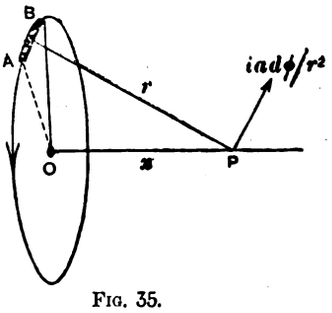

FIG. 35.

Let A B (Fig. 35) be a small portion of the circuit subtending an angle $d\phi$ at the centre O. The length of A B is, therefore, $a\,d\phi$. The radius A P is at right angles to the element A B, so that $\sin\theta = 1$ in this case. The magnetic force at P due to A B is then $i\,a\,d\phi/r^2$ at right angles to A P, and in the plane A O P. Resolving this along the axis we obtain $\frac{i\,a\,d\phi}{r}\times\frac{a}{r}$. The part resolved perpendicular to the axis is cancelled by the effect of the element diametrically opposite to A B. Thus, the resultant magnetic force is along the axis. Adding together the effects of all the elements, we

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find for the magnetic force $F = \frac{i a^2 . 2\pi}{r^3}$. But $r^2 = x^2 + a^2$, so that $F = \frac{2\pi a^2}{(a^2+x^2)^{\frac{3}{2}}} i$, the same expression as we obtained in § 26. If we had taken P at the centre of the circle, then the magnetic force due to the element $a\,d\phi$ would have been along the axis, and equal to $i\,a\,d\phi/a^2 = i\,d\phi/a$. If we make the radius of the circle one centimetre, and take a length of the current equal to the radius, then the magnetic force produced at the centre by this portion is simply i. We might accordingly *define* the unit current to be that current which, when flowing in an arc of wire one centimetre long, bent into the form of a circle of one centimetre radius, produces unit magnetic force at the centre. The promise made in § 23 has now been fulfilled. From the point of view of §§ 31 and 32 this method of definition is very unsatisfactory.

§ 34. **Long Straight Conductor.**—As another example of the formula $i\,d\,s \sin\theta/r^2$ we will find the magnetic force at any point near a long straight wire. We can do this either by direct integration or by a geometrical method. Let P' A P (Fig. 36), be

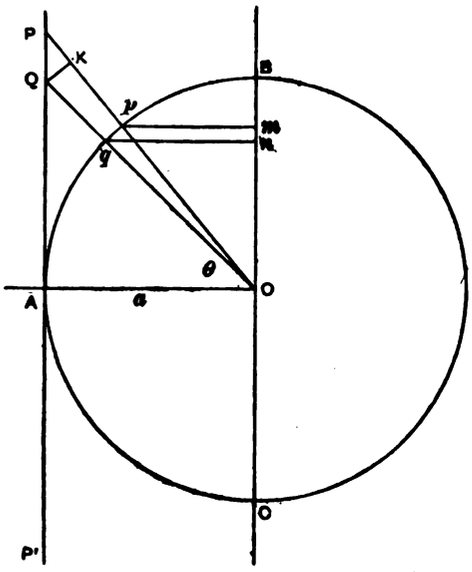

Fig. 36.

the long straight current, O the point at which the magnetic force is to be found. Describe a circle with O at centre touching the wire at A. Let O A = a.

Let P Q be two neighbouring points on the wire, and let O Q = r. Draw Q K perpendicular to O P. Then the magnetic force at O, due to P Q, is $\frac{i\,.\,\text{P Q} \sin \text{Q P O}}{r^2}$ at right angles to the paper. But $\sin \text{Q P O} = \text{Q K}/\text{P Q}$, so that the magnetic force becomes $i\,\text{Q K}/r^2$. If the angle Q O A = θ, then Q K = $r\,d\,\theta$. Thus if F is the magnetic force due to the whole wire $F = 2\int_0^{\frac{\pi}{2}} \frac{i\,d\,\theta}{r}$. But $r = \frac{a}{\cos\theta}$ therefore $F = \frac{2\,i}{a}\int_0^{\frac{\pi}{2}} \cos\theta\,d\,\theta = \frac{2\,i}{a}$.

We arrive at the same result geometrically as follows :—Let O P, O Q cut the circle in p, q. Draw $p\,m$, $q\,n$ perpendicular to the diameter B O C, which is parallel to the wire. Then, by easy geometry $m\,n/p\,q = \cos\theta = a/r$.

Again, $p\,q = \text{Q K}\,a/r \qquad \therefore m\,n = \text{Q K}\,a^2/r^2$.

But the magnetic force at O due to P Q is

$$\frac{i\,\text{P Q} \sin \text{Q P K}}{r^2} = i\,\text{Q K}/r^2 = i.m\,n/a^2,$$

adding together the effects of all the elements of the wire we find that $F = i\,\text{B C}/a^2 = 2\,i\,a$.

We have thus found the same expression as we obtained in § 25 from the principle that the work done in taking a unit magnetic pole round a closed path is 4 π times the current flowing through the space enclosed by the path.

(To be continued.)

THE HEATING OF CONDUCTORS BY ELECTRIC CURRENTS.

The heating of wires by electric currents is a very important subject, which has from time to time received the attention of theoretical writers and of experimentalists. The general law that the current required to maintain wires at a constant temperature varied as their diameter raised to the power of $\frac{3}{2}$ has been brought forward on many occasions since its enunciation by Prof. G. Forbes at the British Association in 1882. In Mr. Preece's Paper before the Royal Society (read April 3, 1884, *The Electrician*, Vol. XII., p. 518) he gave the results of experiments on fine wires used for lightning protectors. He pointed out that for small wires the current varied more nearly as the diameter than as the diameter $\frac{3}{2}$. In Prof. G. Forbes' Paper, read before the Society of Telegraph Engineers, April 24, 1884, this departure from the law was alluded to (*Journal*, Vol. XIII., p. 236). "My own view of the matter is, that while, of course, radiation is proportional to surface, convection is not so, but is nearly constant for rectilinear wires of different diameters at the same temperatures; and that with thin wires, consequently, convection is the most important factor, but for thick wires radiation proportional to surface is the ruling factor." And, again (p. 242), "My impression is that thin wires lose their heat chiefly by convection when free in the air, but larger masses chiefly by radiation." Experiments were quoted to exemplify this, and calculations were given to show "that Macfarlane's constant does not apply to high temperatures, and that the loss of heat is then much greater than in direct proportion to the temperature." In the discussion which followed Prof. Forbes's Paper, curves* were given, showing that the $d^{\frac{3}{2}}$ law, which may be expressed by $C = d^{\frac{3}{2}} \times a$, where C is the current required to raise a wire to any given temperature, d the diameter, and a a constant.

The values of the constant a for different temperatures were given in a curve marked D, and it was observed that "one or two experiments between 100° and 500°C. would give data for plotting the whole of this curve, and from this the emissivity could be determined for any temperature under red heat The relation between the temperature and the constant is approximately satisfied by the empirical formula—

$$c = d^{\frac{3}{2}} \times 54 \times \sqrt[22]{t^\circ},$$

where t° is the temperature above the surrounding air (at 20°C). The departure from the law with very small wires was clearly shown by Mr. Preece's experiments, where a wire of 8 mils took a current of 3·85 amperes to raise it to a dull red heat instead of 3·35."

In the *Electrician*, Vol. XII., p. 541, a very interesting communication from Mr. J. T. Bottomley, commenting on Mr. Preece's work, was published. After discussing the theory of the thermal conditions, he says :—

For round wires of small diameter I have found very much larger emissivity than Macfarlane's $\frac{1}{10000}$th, and, as said above, greater emissivity the smaller the wire. I have obtained different values for wires of different sizes, and for a small wire a numeric as high as about $\frac{1}{100}$th at a temperature of about 70°C.

I do not know that this is to be wondered at, though it certainly was unexpected when we consider the matter in connection with some of the experiments of Aitken on the now celebrated "dark plane," showing the disturbance produced in the air in the neighbourhood of a heated wire.

The result of the whole is that a small wire will lose heat much more rapidly than a large wire under similar circumstances; and I should expect that it would require currents greater for small wires and smaller for large wires than corresponds to proportionality to $d\sqrt{d}$ to maintain the same temperature in them.

P.S.—To avoid misconception I wish to remark that up to the present time I have only experimented at temperatures very much lower than those used by Mr. Preece. I have not yet gone higher than 80° or 85° Centigrade. It is to be noticed that at very high temperatures, such as dull red heat or the fusion temperature of platinum, the separate effects of radiation and of convection, which are included in the theories of Newton and of Fourier under what has been called emissivity in my letter, may hold relations to each other and to the whole phenomenon very different from those which they hold at low temperatures. Thus it is quite possible that at very high temperatures, where radiation becomes predominant, the emissivity for small and for large wires may approximate to be the same. This would correspond to what Mr. Preece has found, though, of course, the subject will require investigation.

* The numbers indicating the ordinates in amperes were misprinted. They should read regularly upwards—5, 10, 15, 20, 25, 30.

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The subject was taken up by Mr. A. Kennelly in 1889, and was most thoroughly examined by him, and a large number of experiments on a large and practical scale were carried out. His Paper, read before the Edison Convention in August, 1889, was published in full in *The Electrician*, Vol. XXIV., p. 142, &c. Nothing of importance has been published since until the reading of a Paper bearing the names of Prof. Ayrton and H. Kilgour before the Royal Society on November 19th last. This Paper deals with "The Thermal Emissivity of Thin Wires in Air." Mr. Kennelly did not pay special attention to thin wires, but his observations include wires from 134·5 to 35·6 mils (about 10 to 20 S.W.G.). The total emissivity of these was observed and curves were given (*The Electrician*, Vol. XXIV., p. 171) not only of the total emissivity, but of the two components, viz., convection and radiation. These two factors are not separated in the abstract of the recent Royal Society Paper. The wires were enclosed in a water-jacket cylinder, the internal diameter of which is not given. It is well known that the temperature of open-resistance coils used for absorbing energy in testing dynamos or regulating arc lamps, is much greater when the axis of the coil is vertical than when it is horizontal; the difference, which was fully discussed by Mr. Kennelly, being due to convection currents of air. It is true that voltmeters, fuses, and some telegraph protectors are more or less enclosed, and such enclosures probably modify convection currents. But they do not stop them, as is demonstrated by the fluttering of a Cardew voltmeter when the wires are vertical. The diameter of the tube in these experiments, or the dimensions of the enclosing chamber in the case of a voltmeter or a fuse, must considerably modify the convection currents, and they will be affected considerably by the temperature of the walls of the chamber. In a Cardew voltmeter the tube is allowed to attain a steady temperature, being heated by the wires; in these experiments it was kept at a constant temperature, which is not given in the abstract. Under these circumstances it does not appear that the results, which are carried to six significant figures, can be generally applied, nor can conclusions as to the emissivity of wires of an inch or more in diameter be safely drawn from calculations based on the behaviour of wires not exceeding 14 mils. The abstract is not full enough to justify further criticism, but it seems that room has been left for further research. The curves which are alluded to were not published with the abstract, but the table is stated to have been drawn up from them. The construction of tables from curves being, as a rule, a reversible process, we have plotted diameters against emissivities, and expected to get something resembling a "family" of rectangular hyperbolas. These would be isothermal lines, and from them emissivities could be plotted against temperatures, as has been done by Mr. Kennelly. But the table yields a set of curves with a decided "hump" at 8 mils, decreasing a little at higher temperatures. In other respects also the curves yielded by plotting this table are not sufficiently satisfactory to be worth while reproducing, and we are inclined to think that some error must have crept into the calculations, or that some peculiar disturbances were present during the experiments. It was evident, therefore, in 1884 that the emissivity depended both on the temperature and on the diameter of the wire. But the variation of emissivity with the diameter being entirely due to convection, no experiments in which convection currents are not considered separately from radiation can be said to deal thoroughly with the effect of decreasing the diameter of the wires

THE THERMAL EMISSIVITY OF THIN WIRES IN AIR.*

BY W. E. AYRTON, F.R.S., AND H. KILGOUR.

In 1884 it was observed experimentally that whereas the electric current required to maintain a *thick* wire of given material, under given conditions, at a given temperature, was approximately proportional to the diameter of the wire raised to the power three halves, the current was more nearly proportional to the first power of the diameter if the wire were *thin*. When this difference in the behaviour of a thick and thin wire was first noticed it was regarded as being quite unexpected. But, as pointed out by one of us in the course of a discussion at a meeting of the Royal Society, the unexpected character of the result was due to people having assumed that the loss of heat from radiation and convection per square centimetre of surface per 1deg. excess temperature was a constant, and independent of the size and shape of the cooling body.

The very valuable investigations that have been made on emissivity by Mr. Macfarlane, Prof. Tait, Mr. Crookes, Mr. J. T. Bottomley, and by Mr. Schleiermacher, had for their object the determination of the variation of the emissivity with changes of the surface and with change in the density of the gas surrounding the cooling body; but it was not part of these investigations to determine the change in the emissivity that is produced by change in the shape and size of the cooling body. Indeed, so little has been the attention devoted to the very large change that can be brought about in the value of the emissivity by simply changing the dimensions of the cooling body, that in Prof. Everett's very valuable book of Units and Physical Constants the absolute results obtained by Mr. Macfarlane are given as the "results of experiments on the loss of heat from blackened and polished copper in air at atmospheric pressure," and no reference is made either to the shape or to the size of the cooling body.

[November 19, 1891. Since this Paper was sent into the Royal Society a new edition of this book has appeared; and, in consequence of a suggestion made to Prof. Everett the word "balls" has been added after the words "copper" in the new edition, as well as the following paragraph:—

Influence of Size.

"According to Prof. Ayrton, who quotes a table in 'Box on Heat,' the coefficient of emission increases as the size of the emitting body diminishes, and for a blackened sphere of radius r centimes may be stated

$$\cdot0004928 + \frac{\cdot0003609}{r}$$

"The value of r in Macfarlane's experiments was 2."]

The laws which govern the loss of heat from thin cylindrical conductors have not only considerable scientific interest in showing how the shape of a body affects the convection currents, but they are of especial importance to the electrical engineer in connection with glow-lamps, hot-wire voltmeters, fuses, &c. We, therefore, thought it desirable to ascertain the way in which the law of cooling for thick wires, which involved the diameter raised to the power three halves passed into the law for the cooling of thin wires, involving only the first power of the diameter. For this object, the investigation described in the Paper was commenced at the beginning of 1888, and the emissivity was measured of nine platinum wires, having the diameters of 1·2, 2·0, 2·9, 4·0, 6 0, 8·1, 9·3, 11·1, and 14 mils, or thousandths of an inch.

Suspecting that some of the published results concerning the currents required to fuse wires had been much influenced by the cooling action of the blocks to which the ends of the wires were attached, we started by making a calculation of the length necessary to give to our wires, so that the loss of heat by conduction should not introduce any important error into the determination of the emissivity. To do this it was necessary to calculate the distribution of temperature along a wire through which a steady current was flowing and from which heat was lost by radiation, convection, and conduction; and it was further necessary to improve on the calculation one of us had published on this subject in *The Electrician* for 1879, by taking into account the fact that the emissivity, as well as the thermal and electric conducting power, of the wire differed at different points in consequence of the difference of temperature.

Until we had completed the experiments described in this Paper we could, of course, only employ in this calculation values that we had guessed at as being something near the truth for the emissivity of platinum wire for different diameters and at different temperatures. Hence, after the completion of the experiments, we took up the mathematical investigation again, substituting for the emissivity such a function of the diameter of the wire and the temperature of the point as we had experimentally found it to be. Section IV. of the Paper contains the investigation by which we finally arrived at the calculated distribution of temperature along the wire, and we have to express our sincere thanks to Prof. Henrici; (whom we consulted as to the best method of practically solving the rather complex differential equation arrived at) for the warm interest that he has taken in the mathematical treatment of the subject, and for the many suggestions which he has made, and which have enabled us to arrive at the mathematical solution given in the Paper.

Each wire to be tested was stretched along the axis of a water-jacketed cylinder 32·5cm. long, the inner surface of which was blackened and kept at a constant temperature by a stream of water flowing through the jacket. The rate at which heat was lost by any one of the wires was measured by the product of the current passing through it into the potential difference maintained between its

* Abstract of a Paper read before the Royal Society, November 19, 1891.

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Diameter of wire in	Emissivities.								Diameter of wire in
Mils.	40°C.	60°C.	80°C.	100°C.	150°C.	200°C.	250°C.	300°C.	Mils.
1·2	0 008230	0·009560	0·010300	0·010846	0 011875	0·012783	0·013625	0·014400	1·2
2·0	0 005950	0·006860	0 007500	0·007900	0·008600	0·009070	0 009480	0·009850	2·0
2 9	0·002193	0 003336	0 004086	0·004552	0·005095	0·005379	0·005628	0·005845	2·9
6·0	0 002460	0·002660	0·002806	0·002930	0 003212	0·003460	0·003666	0·003837	6·0
8·1	...	...	...	0·002804	0·002939	0 003076	0 003217	0·003352	8·1
9 3	...	...	..	0·002297	0·002448	0·002586	0·002718	0·002843	9·3
11·1	...	...	...	0·002053	0 002216	0 002363	0·002490	0 002608	11·1
14 0	...	...	...	0·001894	0·002027	0·002136	0·002224	0 002286	14·0

The wire of 4 mils diameter is omitted from the table, as the experiments showed that its specific resistance was much greater, its temperature coefficient much smaller, and its emissivity much smaller than if it had been of platinum. This piece of wire probably, therefore, contained iridium or silver.

ends, while the ratio of the potential difference to the current gave the resistance of the wire, and, therefore, its temperature. Experiments were in this way made with various currents flowing through each of the nine wires.

As the variation of resistance with temperature is known to vary with different specimens of platinum, experiments were separately made to determine the actual law of variation of resistance with temperature up to 300°C. for each piece of wire that had been employed in the emissivity experiments.

In this later determination various thermometers were used, and the subsequent comparison of these thermometers with a Kew standard thermometer involved a vast amount of labour, from the fact that it is or at any rate was not possible three years ago, to purchase from the Kew Observatory a standard thermometer reading from, say, 200deg. to 300°C., with a short wide chamber at the base in which the mercury expanded below 200°C. All that could be obtained was a long thermometer which had been carefully tested between 0deg. and 100°C., and the remainder of whose tube had been simply calibrated for uniformity of bore. The consequence was that when we desired to compare one of our thermometers reading, say, from 200deg. to 300°C., with the Kew standard, their bulbs were very far apart when both were immersed in the oil-bath, and with the tops of the mercury columns just above the surface of the oil. A short description is given in the Paper of the devices employed to overcome this difficulty and which enables an accurate comparison to be made between the thermometers.

On examining the curves accompanying the complete Paper which show the emissivity for each temperature of the nine wires, we see that :—

1. For any temperature the emissivity is the higher the finer the wire.

2. For each wire the emissivity increases with the temperature, and the rate of increase is the greater the finer the wire. For the finest wire the rate of increase of emissivity with temperature is very striking.

3. Hence, the effect of surface on the total loss of heat (by radiation and convection) per second, per square centimetre, per 1°C. excess temperature, increases as the temperature rises.

On comparing the loss of heat from the wire of 1·2 mils diameter when at 300° C. with that from the wire of 6 mils diameter when at 15° C., both being in an enclosure at 10° C., we see that the former loses per square centimetre of surface per second not

$$\frac{300-10}{15-10}, \text{ or } 58 \text{ times}$$

as much heat as the latter, as it would if the emissivity were the same ; but, instead,

$$60 \times 58, \text{ or } 3{,}480 \text{ times}$$

as much heat ; arising from the fact that the emissivity, that is, the number of calories (gramme C.°) lost per second per square centimetre of surface per 1° C. excess temperature of the 1·2-mil wire at 300° C., being 60 times as great as that of the 6-mil wire at 15°, the latter varying very rapidly with the temperature near 15° C.

From the curves the above table has been drawn up, giving the emissivities of the various wires at eight useful temperatures.

We find that the emissivity of platinum wires of different diameters at the same temperature can be very fairly expressed by a constant plus a constant into the reciprocal of the diameter of the wire. For example, we find that

At 100° C. $e = 0{\cdot}0010360 + 0{\cdot}0120776 d^{-1}$ . . . . . (1),
,, 200 ,, $e = 0{\cdot}0011113 + 0{\cdot}0143028 d^{-1}$ . . . . . (2),
,, 300 ,, $e = 0{\cdot}0011353 + 0{\cdot}016084\ d^{-1}$ . . . . . (3),

where d is the diameter of the wire in mils, or thousandths of an inch.

The emissivities have been calculated in calories lost per second per square *centimetre* per 1° C. excess temperature, in order that they may be compared with the emissivities obtained by other experimenters ; but we prefer to speak of the diameters of the wires in *mils*, since a wire of 1 mil is about the finest that is drawn commercially. Hence the statement that the diameters of wires are 1, 2, or 3 mils is more suggestive to an engineer than saying that they are 0·0254, 0·0508, or 0·0762 millimetre.

The statement, not unfrequently made, that the current required to maintain a wire of a given material at a given temperature above that of the surrounding envelope is proportional to the diameter of the wire raised to the power three halves is equivalent to stating that the emissivity is independent of the diameter. Now from the three formulæ (1), (2), (3), given above for e, we may conclude—

That for a temperature of 100°C. the value of d in the formula

$$e = 0{\cdot}0010360 + 0{\cdot}0120776\ d^{-1}$$

must be something like 220 mils, or 5·6mm., in order that the neglect of the second term may not make an error in e of more than 5 per cent., and something like 1·15 inches, or 29·3mm., if the error is not to exceed 1 per cent.;

That for a temperature of 200°C. the value of d in the formula

$$e = 0{\cdot}0011113 + 0{\cdot}0143028\ d^{-1}$$

must be something like 244 mils, or 6·2mm., in order that the neglect of the second term may not make an error in e of more than 5 per cent., and something like 1·28 inches, or 32·5mm. if the error is not to exceed 1 per cent. ;

And that for a temperature of 300°C. the value of d in the formula

$$e = 0{\cdot}0011353 + 0{\cdot}016084 d^{-1}$$

must be something like 267 mils, or 6·8mm., in order that the neglect of the second term may not make an error in e of more than 5 per cent., and something like 1·39 inches, or 35·3mm., if the error is not to exceed 1 per cent.

Generally, then, we may conclude that to assume that the emissivity is a constant for wires whose diameters vary from a small value up to 1in. is to make a large error in the case of the greater number of the wires, and an error of hundreds per cent. in the case of some of them.

Using the formula (3) which we have arrived at for determining the emissivity of platinum wires of different diameters at 300°C., it follows that to maintain a platinum wire 0·75 mil in diameter at 300°C. would require a current density of 331,000 amperes per square inch ; and, if the emissivity of a copper wire of the same diameter and at the same temperature may be taken as being the same, it follows that to maintain a copper wire 0·75 mil in diameter at 300°C. would require a current density of 790,000 amperes per square inch.

ELECTRIC LIGHTING AND TRACTION NOTICES.

The time for giving official notice in the *London Gazette* of all Private Bills that will be brought forward next Session, and of all Provisional Orders for which application is about to be made to the Board of Trade, has now expired. From the notices thus given it is found that the total number of Private Bills proposed to be introduced into Parliament next year is only 188, and the total number of Provisional Orders that will be applied for is 69. Of the Private Bills no fewer than 24 relate directly to London, among which are a projected railway from Waterloo to the City, a line from Waterloo to Baker-street, and another projected line from Charing-cross to St. Pancras and Hampstead. The existing or authorised electrical railway companies are also promoting extensions from King William-street to Islington, and from the Mansion House to Liverpool-street ; whilst other lines are proposed from Finsbury Park Station to the City, and from the City to Epping Forest.

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Of the Provisional Orders 34 relate to electric lighting; and of the electric lighting Orders 11 are for certain areas in London. In November, 1889, no less than 159 Orders were applied for, and last November the total was 76, of which 17 referred to the metropolis. The number of applications for Provisional Orders tends, therefore, to vanishing point. On the other hand, electric traction notices are, as might be expected, more numerous than was the case last year, when only nine were issued against 15 this year.

ELECTRIC LIGHTING.

THE METROPOLIS.

Districts.	Names of Applicants.
County of London (North).	County of London Electric Lighting Company.
County of London (South).	County of London Electric Lighting Company.
Hackney	East London Electric Supply Company.
Hampstead	Vestry of St. John, Hampstead.
Lambeth	Vestry of Lambeth.
North London...	Camberwell and Islington Electric Light and Power Supply.
St. Mary, Islington.	Messrs. Sharp and Kent.
Shoreditch	Vestry of Shoreditch.
South London...	Camberwell and Islington Electric Light and Power Supply.
West London...	Putney and Hammersmith Electric Light and Power Supply.
Whitechapel ...	Board of Works for Whitechapel District.

Total number of applications 11, of which 4 are by Local Authorities.

PROVINCES.

Towns, &c.	Names of Applicants.
Aberystwith ...	Corporation.
Ashton-under-Lyne.	Corporation.
Brighton	Brighton and Hove Electric Light Company.
Dublin	Corporation.
Fareham	Fareham Electric Light Company.
Govan	Commissioners of Police.
Halifax	Corporation.
Harwich	Corporation.
Horsell and Chertsey.	Woking Electric Supply Company.
Kilkenny.....	Corporation.
Limerick.....	Corporation.
Liverpool	Liverpool Electric Supply Company.
Maidstone	Corporation.
Middlesborough.	Middlesborough Electricity Supply Company.
Newbury.....	Corporation.
Oxford..... (Transfer of Order of 1890 to Oxford Electric Company)	Electric Installation and Maintenance Company.
Sheffield	Corporation.
Sheffield	Sheffield Telephone Exchange and Electric Light Company.
Sutton (Surrey).	Urban Sanitary Authority.
Walton-on-Thames.	Weybridge Electric Supply Company.
Waterford	City of Waterford Electricity Supply Company.
Waterford	Corporation.
West Ham	Corporation.

Total number of applications 23, of which 12 are by Local Authorities.

ELECTRIC TRACTION.

THE METROPOLIS.

Applicants.	Powers sought.
Hampstead, St. Pancras, and Charing-cross Railway (Company to be formed).	To construct a railway running from High-street, Hampstead, to the Strand, and to use electricity or mechanical power other than steam.
City and South London Railway Company.	Extension to Islington.
Great Northern and City Railway (Company to be formed).	Construction of a railway from Finsbury Park to Finsbury-pavement, and the use of electricity or other motive power.
Baker-street and Waterloo Railway (Company to be formed).	Construction of a railway from Baker-street by way of Langham-place to Waterloo Station and the use of electricity.
Waterloo and City Railway (Company to be formed).	To construct a tunnel commencing near James-street, Lambeth, to the Mansion House, to use electricity or cable power.
North Metropolitan Tramways Company.	To construct various tramways and to use electrical and animal power.
London County Council.	Construction of tramway from Westminster Bridge along Victoria Embankment, and the use of electricity or animal power.
Central London Railway Company.	Extension of authorised line from Mansion House-street to Liverpool-street.

PROVINCES.

Applicants.	Powers sought.
Bedford and Kempton Tramway (Company to be formed).	Construction of a tramway and the use of electricity or other motive power.
Corporation of Newcastle-on-Tyne.	Construction of tramways in Elswick and elsewhere. The exclusive right to use animal, electric or other mechanical power.
Corporation of Newport.	Construction of tramways, with use of electrical or other power.
Liverpool United Tramways and Omnibus Company.	To construct various tramways, to use electric or other power.
Somerton, Kimpton, Mandeville, Castle Cary, and Evercreech Tramways.	To construct various tramways, to use electrical or other motive power.
Blackpool, St. Anne's, and Lytham Tramways.	To make agreements with the Blackpool Electric Tramways Company, and use electricity or other motive power.
Liverpool Overhead Railway Company.	Extension of time. Construction of additional works. Use of electricity.

SECONDARY BATTERIES.

BY G. H. ROBERTSON, F.C.S., ASSOC. INST. EL. ENG.

Introduction.

The secondary, or, as it should rather be called, the reversible battery, dates practically from the discovery that electric currents could be produced by the agency of chemical actions, and its development progressed with the increase of our knowledge of the laws which govern electrolysis.

In the year 1800 Volta discovered that a current could be obtained through chemical agency, and in the following year Gautherot observed that when electrodes of silver or platinum wire were used for the electrolysis of acidulated water, they gave a current in the reverse direction to that in which the battery current had been passing, if they were connected through a galvanometer directly the battery was removed.

These inverse or polarisation currents as they were called, were a source of great perplexity; and although much work was done on the subject, and many theories were started to account for their origin by Volta, Ritter, Marianini, Becquerel, Grotthus, and others, no satisfactory explanation was forthcoming until Faraday set the whole theory of electrolysis on a firm basis in his Papers communicated to the Royal Society between June, 1833, and March, 1834.

Although many apparent contradictions have been found to Faraday's well-known simple laws, and the precise mode in which a current is conveyed through an electrolyte is still under discussion; yet his work showed that chemical and electrical energy were mutually convertible, and that the so-called polarisation currents were due to the reversible nature of the chemical changes caused by the passage of the primary current.

The way was thus cleared for improvements in batteries in general, and very many have been brought out; but it was not till much later when Faraday's other great discovery of the laws relating to the conversion of mechanical into electrical energy bore fruit, and provided a cheap source of electricity, that much attention was paid to reversible batteries.

In the course of his experiments on electrolysis he nearly anticipated Planté's discovery of the peroxide of lead—lead couple; for in the case of the electrolysis of a solution of acetate of lead he noticed that on the passage of the current peroxide of lead was formed on the one plate and lead on the other.

In 1843 Grove invented his gas battery, and in 1852 Dr. C. W. Siemens constructed a reversible battery, using carbon plates as his electrodes, and a strong solution of acetate of lead as his electrolyte.

In 1859 Planté made a number of experiments with copper, silver, tin, lead, aluminium, iron, zinc, gold, and platinum voltameters to determine which was the best couple to use for a reversible battery, and decided on the use of lead plates in dilute sulphuric acid, because in discharge both plates were active; that is, not only did the peroxide of lead plate combine with hydrogen, but the reduced metallic lead combined with oxygen; thus the E.M.F. of the cell was due to chemical actions occurring on both plates. In those days the action of the cell was ascribed solely to the decomposition of water, and the effect of the sulphuric acid was left out of account.

In 1872 Planté improved the "formation" of his cell by bringing out the process for alternate reversals of the current; and in the decade which followed, with the improvement of the dynamo, and the consequent growth of electrical engineering, the need for some means of storing electrical energy arose, and the reversible battery passed from the laboratory into commercial use.

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Reversible Batteries.

In 1880 M. Camille Faure invented his cell, in which the electrodes consisted of lead plates, smeared with pastes of red lead and litharge respectively, and covered with a protecting layer of felt. On charging the red lead was oxidised to peroxide of lead, and the litharge was reduced to metallic lead, thus quickly forming a Planté couple of considerable storage capacity.

The same impetus in electrical work which gave rise to the Faure battery led also to the introduction of several other types of reversible batteries ; and as I have been able to obtain very little information about them, I will deal with them and their developments now, before proceeding with the numerous improvements in the two lead types.

Profs. Thomson and Houston have tried electrodes of copper in sulphate of zinc solution ; the plates were laid horizontally, so that the relative weights of the sulphate of zinc and sulphate of copper formed in the working might prevent their mixing too readily. The E.M.F. was the same as that of the Daniell.

M. d'Arsonval modified this battery by making one electrode of lead and the other of zinc, the solution being sulphate of zinc as before. The lead plate forms the positive, and becomes coated with peroxide during charge. According to Miesler the E.M.F. of this arrangement is 2·13 volts.

Sutton tried copper and lead plates in copper sulphate; the E.M.F. being 1·22 volt.

In 1886 M. Dezmazures brought out a modification of the Lalande and Chaperon cell, the solid copper plate being replaced by a porous one made by first reducing copper oxide electrically, and then compressing the fine metallic dust so obtained into plates.* The other electrode was made of tinned iron gauze, and the solution was potassium zincate. The E.M.F. is only about one volt, but the cells are light, and a battery of this description gave satisfaction as a source of motive power at the trials on the French torpedo boat, "La Gymnote," at Toulon. Recently this battery has been tried for traction work in Philadelphia, under the name of the Waddell-Entz accumulator.† In the American form of the battery the copper plates are made of a sort of wire rope, formed of a stout wire core braided over in opposite directions with two layers of wire of different thicknesses, the finest outside. This is again braided with asbestos, or some similar material, which retains and protects the copper oxide formed by electrolysis. The weight of the battery is given as from 55lb. to 60lb. per horse-power stored.

Lead Reversible Batteries.

On the introduction of the Faure cell into England in 1881, great hopes were entertained of it, and the modification in the manufacture of the plates seems almost to have been regarded as constituting a fresh type of cell ; whereas, since the couple was identical, the chemical reactions were the same as in the Planté cell, and any defect due to these would be common to both. As lead reversible batteries cannot be said to have completely realised the hopes then entertained, it is important to discover whether the non-fulfilment is due to causes which can be remedied by improved processes of manufacture, or whether they arise from the chemical reactions occurring in the working of the cell, and are to be met rather by improved treatment after than during construction. I have thought, therefore, that a Paper containing a summary of some of the principal improvements which have been introduced in the construction of the cells, and an account of some experiments dealing with the chemistry of the subject, might lead to some useful discussion.

From a comparison of the two cells made by M. Achard it appears that on its introduction the internal resistance of the Faure was much higher than that of the former, while the Planté cell took longer to form, and was heavier than the Faure. The time required for formation and the weight of the cell were the chief drawbacks to the Planté process of manufacture ; the Faure method had the disadvantage that the applied paste was liable to separate from its support. The remedying of these defects, then, has been the principal aim of the improvements which have been brought out in the two types of the lead reversible battery.‡ To give a complete list of these would be quite beyond the scope of this Paper, but they may be summarised as follows :—

I.—Improvements in the Planté type, *i.e.*, that in which the peroxide of lead and spongy lead are formed direct from metallic lead by electrolysis.

In this type, since both the weight of the plate and the time required for "formation" can be shortened by making the plate porous, and thus exposing more surface to the action of the acid and charging current, obtaining porosity has been the chief aim of inventors. The methods which have been suggested from time to time may be classified under three headings :—

A. Chemical.—The plates are subjected to some "pickling" process, or some special "forming" bath is used.

B. Mechanical.—The plates are made of granulated lead, wire, or some form of finely divided lead.

C. Electrolytic.—(1) The finely divided lead is obtained by the electrolysis of some salt of lead. (2) Some salt of lead is formed into a plate by pressure, or otherwise, and then reduced to metallic lead.

I.—Improvements in the Planté Type.

Chemical Processes.—Planté found that plates of lead which had been steeped for a long time in dilute sulphuric acid, before being submitted to the action of the charging current, "formed" more rapidly than those which had not been so treated, and he also found that "formation" was hastened by heating the cell during the process ; this, however, was difficult in practice.

In 1882, in order to roughen the surface, he pickled the plates for from 24 to 28 hours in a bath composed of nitric acid, diluted with from once to twice its volume of water. The plates were then thoroughly washed, and the formation completed in a bath of dilute sulphuric acid 1 to 10. By this improvement he stated that a capacity, which under the old process took several months to obtain, could be acquired in eight days.

Almost simultaneously, Messrs. Elwell and Parker suggested the use of a mixture of nitric and sulphuric acids as a pickling bath. Since then different baths containing nitric acid in varying proportions have been brought out, and from the earliest times the addition of some salt of the alkalies, such as ammonium, sodium, potassium, or magnesium sulphate to the electrolyte during formation has been suggested as an improvement.

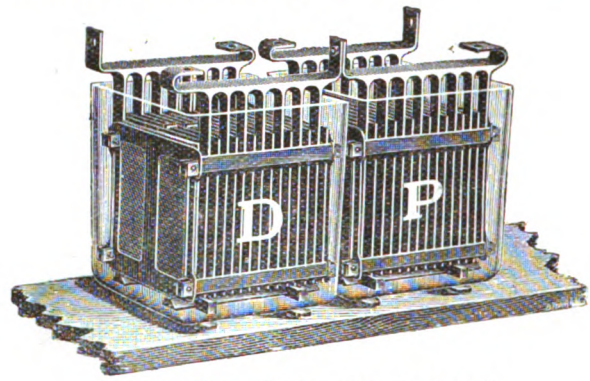

Fig. 1.—Messrs. Drake and Gorham's Cell.

In 1884 Mr. FitzGerald proposed the use of phosphoric acid ; and in the same year Mr. Tribe experimented with plates partially or wholly converted into sulphide, phosphide, or arsenide, prior to "forming" them by electrolysis.

Coming to recent processes, in 1890 Mr. Epstein suggested first boiling the electrodes in a bath containing 1 per cent. nitric acid, 1 per cent. potassium permanganate ; or else, in lieu of the permanganate, 2 per cent. carbonate or sulphate of sodium, or 1 per cent. sulphate of manganese. The plates are dried in air, and then "formed" by the action of the current in an electrolyte containing acetic, phosphoric, or tartaric acid in the proportion of ½ to 2 per cent.

A few months later Dr. Paul Schoop brought out his process for first subjecting the plates to the action of a current of about one-sixth of an ampere per 100 sq. c.m. at 50°F., in a bath composed either of 100 parts by weight ammonium sulphate, 140 parts by weight sulphuric acid (50 deg.), two-thirds one part by weight potassium chlorate ; or else, 100 parts by weight water, 5 parts by weight sodium bisulphate, two-thirds one part by weight potassium chlorate. The treatment is continued for from 36 to 100 hours, according to the depth of the active material required. The formation is completed in ordinary dilute sulphuric acid.

Mechanical Processes.

Messrs. Crompton and Howell's well-known plates, formed by the compression of a specially porous granulated lead, are an instance of this type, and from their great porosity they are capable of a very high rate of discharge.

In Messrs. Drake and Gorham's cell (Fig. 1), both plates are formed of roughened strips of lead, laid horizontally one over the other, and connected by their ends to upright rods. From its

* *The Electrician*, Vol. XXII., p. 302.

† *The Electrical Engineer*, Vol. VII., No. 23, p. 556.

‡ For an account of the lead batteries on their first introduction into commercial work, and of the early suggestions to replace them, see a Paper by Prof. W. Grylls Adams, F.R.S., read before the Science Society of King's College, October 25, 1881, and published in *The Chemical News*, Vol. XLV., p. 1. In Mr. Niblett's Paper on "Some Recent Improvements in Lead Secondary Batteries," read before the Physical Society of Glasgow University last January, and published in *The Electrical Engineer*, Vol. VII., Nos. 13 to 17, will be found an account of the principal structural improvements which have since been effected.

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construction this plate is free to expand and contract without injury to itself.

In Mr. Niblett's so-called "solid cell" * the electrodes are separated by porous partitions, and the space between the electrodes and the partitions is filled up with granulated lead. In this cell there is practically no free electrolyte to wash about and spill; it is all absorbed either in the mass of spongy material forming the electrodes or in the porous partitions.

Plates have also been made of compressed lead dust, of wire loosely woven and compressed, as in Reynier's cell; or in the form of rope, as in the Legay cell.

M. Bandsept's plates would appear to be of this type, as they are made of extremely finely pulverised material, which is then compressed into briquettes, and subjected to a forming process. The cell is now in use commercially in Brussels, but very little information can be obtained about it.

Electrolytic Processes.

1. *The Electrolysis of some Lead Salt Solution.*—The acetate of lead has been frequently employed for this purpose since Siemens used it; and another salt that has been the subject of many patents is the chloride of lead. In America last year it was proposed by an Englishman named Currie, to form the electrodes of rods or bars of lead, coated with woven asbestos. These electrodes are then placed as anodes in a bath of zinc chloride, and lead chloride to the required depth is formed on them, while zinc is deposited on the cathodes. On reversing the current, spongy metallic lead is produced on what are now the cathodes, and the zinc goes into solution, being thus used over and over again.

2. *The Reduction of a Plate formed of some Salt of Lead.*—Perhaps more patents have been taken out under this heading than any other. Plates have been formed of the fused chloride, cerussite, or the native carbonate, has been compressed into plates, and in fact any salt of lead, even lead sulphate, which can be got to reduce to metallic lead by the action of the current, has been employed.

In the Laurent-Cely cell the plates are composed of pastilles of specially prepared lead chloride, round which frames of an alloy of lead and antimony are cast. By the action of zinc in very dilute hydrochloric acid, the plates are converted into cellular lead. The plates are then washed in cold water, dried, and the positives converted into litharge by the action of a current of hot-air. The formation is then completed by electrolysis in the usual way.

For this cell it is claimed that the density of the positives is 4·3 to 5, while that of the negatives is only 3 to 3·5. Great storage capacity for weight is also claimed.

II.—Improvements in the Faure Type.

II. Improvements in the Faure type, *i.e.*, that in which the perioxide of lead and spongy lead are formed by electrolysis from some oxide applied to the plates.

As in this class of cell the active material is applied to the electrodes, and not formed from them as in the original Planté cell, it is obviously desirable that the supporting part of the electrode should be light, and not weakened by taking part in the chemical reactions. These requirements have been met in many instances by replacing the solid lead plate by a grid, usually made of an alloy of lead and antimony, since such an alloy is less acted on by the acid, and is much stronger than pure lead.

In the E.P.S. cell the use of an alloy of lead and antimony was abandoned, because if sufficient antimony to obtain a good casting was added, the grid was so hard that it did not yield to the expansion of the paste, which consequently forced itself out of the plate. Lead grids were then employed, but now they have been abandoned for rapid discharge work, and a solid plate has been reverted to.

In the latest form of Mr. Fitz-Gerald's lithanode cell weight is reduced by making the support of a light double frame of copper wire, protected from the action of the acid by dipping it first in soldering fluid, and then in molten lead.

The other improvements fall into two principal divisions:—A. Those which have for their object the retention of the paste on the plate, and they may be classed under four headings. B. Those intended to provide better connection between the support and the active material.

A. The Retention of the Paste.—1. The plate is not perforated, but grooves or recesses are made on the surface; or it is cast with projections from it so as to afford a lodgment for the active material.

The Tudor plate is a familiar instance of this type, which has the advantage that the support gradually gets "formed," and supplies active material to replace that lost in the working of the cell. In the new 1890 pattern E.P.S. plate an early form introduced originally by Swan has been resorted to. The plate is grooved horizontally, as in the Tudor plate, and the ridges between the grooves curve slightly upwards towards the surface of the plate, forming a lodgment for the paste.

2. The support is some form of grid, that is, is perforated with holes as in the old pattern E.P.S. plate and the Julian grid (Fig. 2).

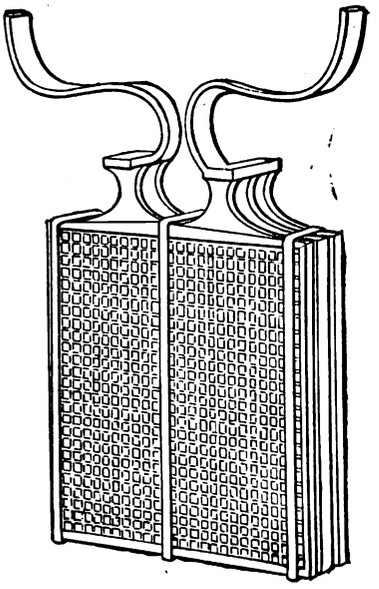

Fig. 2.—Element Consolidated Electric Storage Company

A great many varieties of this form of plate have been suggested, and the apertures have been made by casting the grid in a mould, and by punching. Their form has been cylindrical, barrel-shaped as in Messrs. Drake and Gorham's old positive plates, shaped like two cones joined at the apices, and to give greater security the perforation has been made to expand again just at the junction of the apices.

(To be continued.)

* *The Electrical Engineer*, Vol. VIII., No. 4, p. 80.

DESCRIPTION OF THE STANDARD VOLT AND AMPERE-METER USED AT THE FERRY WORKS, THAMES DITTON.*

BY CAPTAIN H. R. SANKEY AND F. V. ANDERSEN.

(Concluded from page 95.)

Calibration of Galvanometer.—Fig. 3 shows the connections and general arrangement. A current is established by means of two or three secondary cells through two suitable rheostats, one having a fixed and the other a variable resistance, the latter made of mercury placed in grooves of a wooden trough with two copper slides. The strength of this current is varied by adjusting the mercury rheostat until the fall of potential across the fixed resistance—"A" on the diagram, Fig. 3—the terminals of which are connected with two

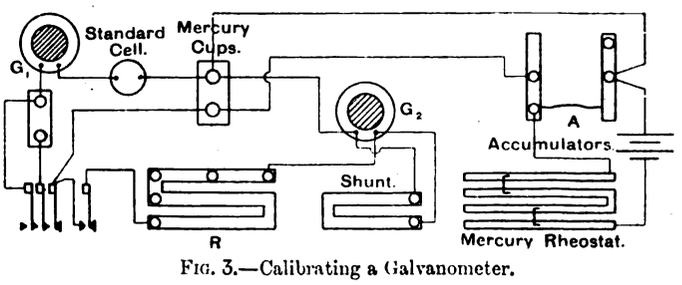

Fig. 3.—Calibrating a Galvanometer.

mercury cups on the instrument table, is equal to the E.M.F. of the standard cell. The balance is effected by placing a standard cell joined in series with a second galvanometer in opposition to the potential difference between the two mercury cups, and adjusting the mercury resistance until no deflection is obtained on the second galvanometer. The galvanometer to be calibrated forms with an adjustable resistance box in series, and generally with a shunt across its terminals, a circuit between the same mercury cups. When no deflection is obtained on the second galvanometer, the fall of potential across the circuit of the galvanometer under calibration is equal to the E.M.F. of the standard cell. Clearly,

* Paper read before the Institution of Electrical Engineers.

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therefore, the current in the galvanometer can be easily found by means of the formula,

$$c = \frac{e}{m\,R + G} \quad \ldots\ldots\ldots \quad (5)$$

c = current through galvanometer.
m = multiplying power of shunt on G.
R = resistance in series with G.
G = ,, of galvanometer.

As a practical matter, the values of R based on the use of a certain shunt are calculated beforehand, so that the current shall be 10, 20, 30 . . . . micro-amperes ; and the observations are noted as shown on Table III., which gives the calibration of galvanometer No. 1,588, taken on April 22 last.

In the circuit of the standard cell a key is used which has double contacts, and is connected with a high resistance (about 10,000 ohms) in such a manner that, when the key is depressed half-way, this resistance prevents an injurious current from passing through the cell, whilst, when the key is completely depressed, after the balance has been very nearly established, the resistance is short-circuited, and so the full sensitiveness of the arrangement obtained.

When the potential difference between the mercury cups is equal to the E.M.F. of the standard cell no current passes through the second galvanometer, the spot of which will move visibly for a current of one ten-millionth of an ampere. As the internal resistance of the standard cell plus the resistance of the galvanometer does not exceed 1,600 ohms, a visible deflection is obtained, one way or the other, if the balance is at fault to the extent of $\frac{1}{10^7} \times 1{,}600$, or ·00016 volt, which is about ·011 per cent. of the value of the standard cell.

The mercury varying but little in resistance by temperature, and giving perfect joints with the copper slides, allows of the resistance of the mercury rheostat being adjusted with any desired accuracy, and remaining practically constant when once correctly adjusted. The delicacy of this electrical balance is so great that a movement of 1-64th inch of one of the slides is sufficient to cause a deflection on the second galvanometer.

This balance is tried for each reading when calibrating a galvanometer.

Table III.

Calibration of Galvanometer No. 1588, 22/4, 1891.

Temperature of cell and instruments, 14·5°C.
E.M.F. of cell, e = 1·4386 volts (legal).
Resistance of G = 430·9 ohms ,, (measured).
Resistance of shunt = 47·9 ohms ,, = $\frac{1}{9}$ G.

Current in G $= c = \frac{10^5 e}{R + \cdot 1\,G}$ micro-amperes.

$$\therefore R = \frac{10^5 e}{c} - \cdot 1\,G = \frac{143{,}860}{c} - 43\cdot 1 \text{ legal } \omega \quad \ldots\ldots\ldots \quad (6)$$

Column II. contains the values of R worked by this formula for the desired values of c in column I., and column III. gives the observations obtained in each case ; each reading being the mean of three observations.

I. c.	II. R.	III. D mm.	IV. $\frac{\Delta c}{\Delta D}$
5	28,729	11·3	·4348
10	14,343	22·8	·4464
20	7,150	45·2	·4386
30	4,752	68·0	·4367
40	3,553	90·9	·4425
50	2,834	113·5	·4444
60	2,355	136·0	·4474
80	1,755·2	180·7	·4514
100	1,395·5	225·0	·4444
120	1,155·7	270·0	·4395
140	984·5	315·5	·4395
160	856·0	361·0	·4348
170	803·1	384·0	...

From the calibration in Table III. the volt scale was constructed on the white margin immediately below the millimetre scale by simply projecting the points of the readings in column 3 downwards by means of a set square and dividing up the sections into units. The ratios $\frac{\text{difference of current}}{\text{difference of deflection}}$ contained in column 4 of Table III. show that the deflections are fairly proportional to the currents. Some allowance is to be made for inaccuracies in the millimetre scale apart from errors of observation.

The calibration of the ampere galvanometer G_1 and the manufacture of the ampere scale were done in the same manner as here described.

These calibrations have been repeated several times at intervals, besides which frequent calibrations of mean readings have been taken—formulæ 2 and 4 in the preceding.

It has been found that the constants of the two galvanometers have not altered beyond 1-5th per cent. during six months, except on two occasions when the levelling of the instruments had been interfered with.

For purposes like these measurements a D'Arsonval galvanometer should have a glass front to the case, so that the coil is clearly visible, and there should be means of verifying and adjusting the position of the coil in the field. The coil should be wound on a metallic (aluminium) frame, to prevent changes in its shape ; and there should be a torsion head outside the cover, so that the original zero of the coil in the field can be restored without opening or interfering with the instrument.

As a slight set crept into the suspending wires of the two galvanometers used in the apparatus, and as they had no arrangement for restoring the zero, it became necessary to turn the instruments on their bases, as the position of the scales could not be altered. The effect of the shifting was hardly noticeable on one of the instruments, but it caused an alteration in the constant of the other to the extent of 1·2 per cent, and a discrepancy of ·3 per cent. in the proportionality of the scale, which necessitated re-graduating it. An alteration in the constant alone can, of course, at once be balanced by a correction in the resistance used in series with the instrument.

New instruments fulfilling the above conditions are being made.

Main Ampere-Rheostat.—This rheostat, which is marked B on the diagrams, is made of 40 platinoid strips, 6 feet long each, all joined in parallel between two copper terminal bars. The thickness of the strips is ·03 inch ; the total width = 38 inches. The cross-section is 1·14 square inches ; the resistance is ·0010882 legal ohms at 17°C. The total surface of the strips, including the two terminal bars, is 5,854 square inches. When carrying 1,000 amperes 1,088·2 watts are consumed by the rheostat—*i.e.*, power is given off to the atmosphere at the rate of ·186 watt per square inch of surface, which has been found to cause a rise of temperature near the centre of the strips of very nearly 20°C. The rise of temperature in this rheostat has been observed with different currents, and has been found to be proportional to the square of the strength of the current.

The arrangement used for determining the resistance of B is shown on Fig. 2. It will be seen that B is placed in series with another rheostat, A, and with the mercury rheostat previously mentioned, and that the circuit further contains a few secondary cells. The current in this circuit is adjusted by the mercury slide resistance until the fall of potential across resistance A is equal to the E.M.F. of the standard cell, which is ascertained by means of galvanometer G_2 in the manner described previously when the calibration of the galvanometers was dealt with. The deflection is then read on the scale of galvanometer G_1, which is joined (with a resistance box in series) across the terminals of B. The resistance of rheostat A, as well as the value of the deflection on G_1 and of the resistance R in series with it, being known, the necessary data for finding the resistance B are to hand. This resistance is obtained from the formula,

$$B = A/e\,c\,(G_1 + R)^* \quad \ldots\ldots\ldots \quad (7)$$

where e = E.M.F. of standard cell ;
c = the current corresponding to the reading on G_1.

Table IV. contains the results of two determinations of B obtained at different dates.

Table IV.

Determinations of Resistance of Main Ampere-Rheostat.

Date.	Number of experiments.	Resistance of B.	Remarks.
2nd April, 1891.	8	·0010882 (reduced to 17°C)	Currents used through B = 29·63 and 49·36 ampere.
21st July, 1891.	3	·0010869 (reduced to 17°C)	Current through B = 49·04 ampere.

Rheostat A.—As is seen from the preceding part of this Paper, the accuracy with which currents can be measured in the present system depends upon the knowledge of the value of the resistance of this rheostat. Great care was therefore taken in its manufacture and adjustment. It consists of five strips of platinoid, each intended to carry 10 amperes without material warming. The end of each strip is soldered to a massive gun-metal block let into a wooden frame. These blocks have holes drilled in them about $\frac{3}{4}$in. diameter for use as mercury cups. Two heavy strips of gun-metal are let into the frame, one at each end, and there are also holes in these strips opposite the holes in the blocks. The connections are made by thick copper bridge-pieces. By this arrangement the strips can be placed either in series or in parallel, and one or more of the strips can be placed in the circuit.

* For $e/A\,B = c\,(G_1 + R)$.

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The resistance of each strip is arranged so that the fall of potential across it when a current of about 10 amperes is flowing through it is equal to the E.M.F. of the standard cell.

The absolute resistance of the strips could have varied within certain limits, but it was necessary to adjust the resistance of each to equality with a considerable degree of accuracy. As there was no means of doing this at Thames Ditton, the resistance was taken to the Ordnance Survey, Southampton, about two years ago, and the adjustment made by scraping the strips until their resistances were equal.

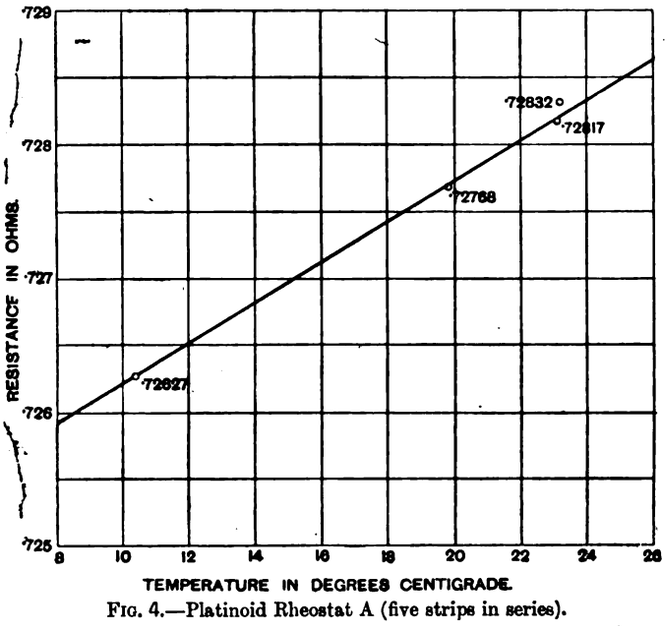

FIG. 4.—Platinoid Rheostat A (five strips in series).

The resistance of the five strips in series was then taken at different temperatures, and as there are special arrangements at Southampton for keeping the temperature of the testing-room constant, the temperature of the platinoid strips could be accurately determined at the time when each resistance test was taken. The results of these tests are given in Fig. 4. The balance was made against the Ordnance Survey standard ohm (legal).

At Thames Ditton the resistance of the strips has been determined from time to time by a direct comparison with the Thames Ditton standard ohm in the manner shown in Fig. 5. It will be

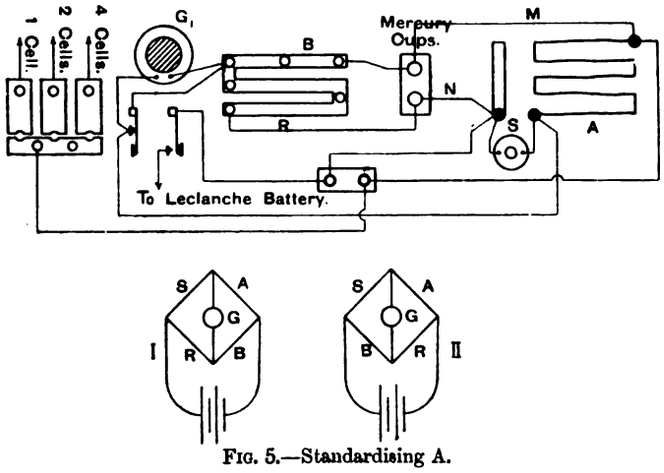

FIG. 5.—Standardising A.

seen that the resistance and the ohm form two arms of a Wheatstone bridge arrangement, and boxes of coils the other two arms, as shown by the two small diagrams I. and II. (Fig. 5). The adjustable resistance R is first placed in one arm, and then in the other, so that the resistance A of the strips is found by the equation,

$$A = S\sqrt{\frac{R_2}{R_1}}. \quad \ldots\ldots\ldots \quad (8)$$

where

S = the resistance of the standard ohm at the given temperature;

R_1 and R_2, the values of the adjustable coils in the first and second measurements respectively.

The only alterations required in the connections in going from the first of the two tests to the second is the changing of the two leads, M and N, in the mercury cups.

It will be observed that by this arrangement no allowance has to be made for leads, and the absolute resistance of the box of coils is immaterial; true proportionality only is required; thus the temperature of the box of coils does not affect the result.

Fig. 4 shows that the resistance of the five platinoid strips rose from ·7262 ohm to ·7280 ohm for a rise in the temperature from 10° to 22°C., which gives a temperature coefficient of ·0207 per cent. per degree Centigrade. At 14·8°C. the value, according to the tests at Southampton, is ·72693. The test at Thames Ditton gave ·72659, leaving a discrepancy of ·047 per cent.

Surface Leakage.—One way of quickly making a test of the state of the instruments is to send a current from the testing cells through the rheostat B, with the connections as in Fig. 2, which, when the instruments are not in use for other purposes, can be done by merely turning on a switch, and read the value of this current on the ampere galvanometer with various constants, altering the resistances in series according to Table I. When this experiment was tried after the instruments had been out of use during the Easter holidays, the galvanometer gave a higher value for the current with constant ·5 than with constant 1, and with constant ·1 still a higher value than with ·5. This discrepancy, which amounted to no less than 3 per cent., was found to be due to surface leakage, which was greater with the higher constant obtained by higher resistance in series. It disappeared completely by a slight rubbing of the top of the resistance boxes with a piece of leather.

The considerable error mentioned was obtained with a current of about 40 amperes, producing a potential difference across the instruments of only about ·043 volt.

DISCUSSION.—AUTHORIZED ABSTRACT.

Mr. GISBERT KAPP said he understood that the platinoid sheets of rheostat A were sometimes used 5 in series (as in Fig. 2 of the Paper) and sometimes 5 in parallel, and he would like to know how the change was effected without introducing unknown resistances.

Prof. AYRTON said he was glad to see that the authors were supporters of the deflectional method of measuring amperes and volts, in preference to the zero method so often adopted. There were several points in the present Paper with which he differed. In the first place he would like to know why galvanometers of comparatively high resistance were used, and why they were wound with copper. For the current measurements, a low resistance instrument would have been decidedly preferable, and both galvanometers ought to have been wound with platinoid. The ampere meter would then require no correction for changes of temperature of the room. He enquired whether any special arrangement had been adopted to make the deflections of the galvanometers proportional to the currents. Putting curved pole pieces on the magnets and allowing the coil to hang freely from the top suspending wire would give the desired result. He thought the authors of the Paper had overstated the range of their amperemeter by giving it as from $\frac{1}{40}$ to 1,100 amperes, for the former current only gave a deflection of about one thousandth of the length of the scale, and therefore could not be measured with any approach to accuracy. Referring to the voltmeter instrument he enquired whether the error introduced by shunting part of the potentiometer P (Fig. 1 of Paper) by the galvanometer and resistance R had been allowed for; in some cases given in Table II., neglecting this would introduce an error of 0·5 per cent. He was of opinion that standard instruments for workshop or factory use should require no constants and no adjustment of resistances to vary the constant, but that different scales should be used, each graduated to read directly, and the resistances altered automatically by the act of changing the scale. Such an arrangement was fitted up three years ago at the Acme Works, six scales being mounted on an hexagonal roller, the turning of which automatically inserted the proper resistance in series with the D'Arsonval galvanometer to make the corresponding scale read amperes or volts direct. Only one scale was visible at one time, so there was no possibility of mistake. Weakening of the magnets was compensated by a magnetic shunt provided with a fine adjustment. Speaking of the change of sensibility of D'Arsonval galvanometers with time he said that of the two instruments at the Central Institution above referred to, the original form had changed more than 3 per cent. in three years, whilst the modified form had remained perfectly constant since the alterations were made about two years ago. The change of sensibility he believed was due to the oxidation of the German silver suspension wires, whilst the other instrument, being suspended with phosphor bronze strip, had remained constant.

Captain SANKEY further described the resistance A used as an intermediary between the standard ohm and the rheostat B, and explained a diagram of it. He showed that there were two mercury contacts at the ends of each strip, and these were in parallel when the strips were in parallel. There were thus ten contacts in parallel at each end, and calling the resistance of each contact m and that of each strip s the resistance in parallel will be $s/5 + 2/10\ m$. When the strips are in series there are five mercury contacts in series, and the resistance is $5\ s + 5m$. The parallel is therefore one twenty-fifth of the series resistance, the mercury contacts being eliminated. Recent tests of the resistance A when in series gave 0·72678, and one twenty-fifth of this was 0·0290712. Direct measurement of the parallel resistance gave in two instances 0·029082 and 0·029075. He had tested a Siemens electro-dynamometer by the apparatus and found its constant to be 28·50. The instrument was then sent to the makers to be recalibrated, the new constant being 28·41. The original constant was 28·67, and hence his determination was equal to the mean of the two given by Messrs. Siemens Bros. Two errors in Table I. of the Paper were pointed out; in column 3 line 4 the number 0·417 should read 0·0104, and in column 4 line 3 the number 1·66 should be replaced by 1·57.

Prof. AYRTON exhibited several diagrams illustrating his previous

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remarks, and showed several of the latest types of d'Arsonval galvanometers. He expressed his high admiration of the most perfect arrangements provided by Messrs. Willans and Robinson for testing the efficiencies of their steam engines, and he made some suggestions as to how their electrical test apparatus might be modified. The arrangement of platenoid sheet and d'Arsonval galvanometer used as a standard amperemeter at the Central Institution, and also the hexagonal multiple scale fitted up at the same works, were illustrated by diagrams, and the secular variations of sensibility of d'Arsonval were shown by means of tables. Referring to recent forms of instruments, he showed two new d'Arsonvals, both provided with adjustable magnetic shunts. One of these had been made by Mr. Pitkin, and the other by Messrs. Nalder Brothers and Co., the coil of the former instrument being wound with "manganin" wire, and that of the latter with platinoid. Both instruments had curved poles and freely suspended coils. Carpentier's long range d'Arsonval, an instrument deflecting through 180 degrees, was exhibited, together with a shunt, by means of which the sensibility would be greatly varied. Speaking of the shape which should be given to the coils of d'Arsonval galvanometers, he called attention to a note on the subject, presented to the Physical Society in March, 1890, by Mr. T. Mather, and he exhibited an instrument embodying the improvements there suggested. This galvanometer had a long narrow coil and no iron core, and for its winding was the most sensitive d'Arsonval he (Prof. Ayrton) had yet tested. On the subject of platinoid sheet rheostats, he said that instead of using a large surface 6ft. by 2ft. 2in., as Capt. Sankey and Mr. Andersen did, it would be better to have two sheets, one for currents, say, from 5 to 110 amperes, and the other from 50 to 1,100. If the narrow-coil low-resistance instrument mentioned above be used, the former platinoid sheet would require be be about 5in. square, and the latter 15in. square. With these the same range of current could be measured as with Capt. Sankey's large rheostat, and no temperature corrections whatever need be made to obtain an accuracy of one-fifth per cent. Further, the expenditure of power when measuring 1,100 amperes would only be 40 watts, whereas the strip described in the Paper absorbed about 1,300 watts when measuring the same current. The mercury contacts, although nominally eliminated, were nevertheless a source of uncertainty, and where the value of a resistance was of such vital importance their use should be avoided. Some of his students had recently tested such contacts and found them to vary greatly according to their condition, in one case the resistance fell from ·00266 to 0·00058, on being cleaned and reamalgamated.

Mr. CROMPTON said he wished to call attention to a few points which appeared to have been misunderstood. In the first place some persons said the Paper under discussion was unworthy of the Institution; with this he entirely disagreed, and thought the idea arose from misconception. He himself considered the Paper a capital one to commence the session with, and particularly interesting to rising electrical engineers. The details of practical testing apparatus were always valuable, and little dodges of great use to others always accompanied Papers such as the one before them. Again, English electrical engineers had established what was known as the English system of arranging central stations, viz., the combination of high-speed engines with direct driven-dynamos. Efficiency tests of this system showed that it gave better results than any other system. The Institution of Civil Engineers had acknowledged the completeness and accuracy of the "engine efficiency" tests of Messrs. Willans and Robinson; and he (Mr. Crompton) thought the electrical tests made as described in the Paper were quite accurate enough for present requirements. Speaking as one who had paid considerable attention to accurate electrical measurements, he doubted whether resistances could be measured to 1 part in 10,000, as stated in the draft Order in Council prepared by the Board of Trade. He had made many tests, and taken the greatest pains to obtain accuracy, but he found that it was not possible to get resistance boxes sufficiently well adjusted. Surface leakage difficulties were also very great, particularly in a London atmosphere. In their measurement at Chelmsford they preferred the zero method, and used d'Arsonval galvanometers, Clark's cells, and potentiometers. The chief reason for the preference was that it was so easy to repeat a measurement, and errors were so readily detected. He inquired why Prof. Ayrton had not used electromagnets instead of permanent ones in d'Arsonval galvanometers, in some such way as Mr. Kapp and himself had done in ammeters and voltmeters some years ago. At present he was engaged on an electromagnet instrument, which he hoped would be a great improvement on any yet made.

Mr. SWINBURNE described the system of measurement explained in the Paper as a calibrating system. In most station work it was usual to employ amperemeters and voltmeters, and he thought this would continue. Such instruments were, however, of two classes, the accuracies of which were very different. It would not be satisfactory to use a voltmeter intended for house work, and costing 3 or 4 guineas, in a station where an accuracy of a fraction of a per cent. was required. A letter balance was a very good thing for its purpose; but it would be totally unfit for chemical weighings. Captain Sankey and Mr. Andersen had, he understood, put up the arrangement described because they could not put confidence in other people's calibrations; neither could he himself, but a good instrument calibrated by the user would, he believed, be more satisfactory than the arrangement now before the meeting. He objected to "spot watching" in central stations, and thought the d'Arsonval galvanometer would not stay. A voltmeter might be accurately calibrated just as well as a d'Arsonval galvanometer. Most of the tests depended on standard cells, and considerable difference of opinion existed with regard to their reliability. If made in the same way from the same materials good agreement could be obtained between different cells, but this did not say they were right. Other persons were sceptical about the reliability of double-wound series resistances; and to examine this point his assistant, Mr. Bourne, made a coil of two insulated wires wound side by side. The insulation resistance was found to be over 600 megohms, and the insulation did not break down until the pressure between them amounted to 950 volts. This he considered proved that they were quite reliable. On the subject of platinoid he inquired whether its properties were permanent, and said that he could find no tungsten in it, and thought it was merely German silver with a large proportion of nickel. Speaking of resistance measurements he said that for small values the fall of potential method was the most suitable, and by it a single bar of an armature could be easily tested. With reference to the use of electromagnets mentioned by Mr. Crompton, he said that Mr. Boys had tried them, and found little or no advantage. Thomson galvanometers were much more sensitive than d'Arsonval's, and the only drawback was their being affected by external fields; but even this was not very important in null methods. In conclusion, he rather objected to a statement by Prof. Ayrton about the arrangement described by the authors being accurate enough for workshop purposes, and he pointed out that the most accurate measurements made, those of weight and length, were made in workshops; the former in commercial analysis, and the other by Whitworth measuring machines.

Mr. S. EVERSHED was surprised that more attention had not been paid to inaccuracies inherent in the instruments, for in addition to the variation of resistance with temperature, springs, torsion wires, magnets, &c., had temperature coefficients which ought to be investigated. Good magnets, with fairly closed circuits, were very permanent when left untouched; and he had used a tangent galvanometer with permanent magnet control for several years as a standard amperemeter, and the change had been very small. The magnets of one d'Arsonval galvanometer he tested had a temperature coefficient of about 0·01 per cent. This was considerably lower than those usually found for magnets used in magnetic observations (0·02 to 0·03 per cent.), but several samples of Jowitt's steel, tested by Mr. Vignoles, gave about 0·01 per cent. per °C. He therefore thought the ordinary coefficient was between 0·01 per cent. and 0·02 per cent. Speaking of the position of the point of attachment of the potential wires on the platinoid strips, he said they should be placed at some distance from the ends, so that the flow of current in the strip may be properly distributed. The new alloy "manganin" was, he believed, first tested in England by himself. The temperature coefficient, when received from the maker, was very small, and was negatived, but on having a wire drawn down to a smaller size its coefficient became positive. On inquiry he learned that to prevent this occurring a special method of drawing had to be adopted. Another specimen had a temperature coefficient about − 0·01 per cent. per °C. between 0deg. and about 160°C., but on keeping it heated to 160deg. its resistance fell considerably, and its specific resistance was permanently altered; its temperature coefficient was, however, about the same. From this he concluded that if permanency was required it should never be heated above 100°C. There was one form of d'Arsonval's galvanometer, which, although it had not been referred to, was worthy of attention, viz., the Weston voltmeter. He had recently tested one, and found it remarkably good and very accurate.

Mr. A. P. TROTTER wished to compliment the authors on the successful system they had carried out. He said it should be borne in mind that there were three classes of measurement carried out respectively in laboratories, workshops, and instrument-making factories. When the Society of Telegraph Engineers was first founded resistances were measured in miles of telegraph wire, and electromotive forces in Daniell cells; subsequently, when the name was changed to Society of Telegraph Engineers and Electricians, laboratory methods were employed; but now, as electrical engineers, it was necessary to measure in an engineering fashion. He considered the method adopted at Messrs. Willans and Robinson's a laboratory one, and thought the d'Arsonval galvanometer had not come to stay for workshop use, for "spot-watching" was not acceptable to engineers. Quartz fibres had revolutionised Thomson instruments, and they were highly sensitive and reliable. At present he did not see that workshop electrical measurements need be made to an accuracy of less than one in a thousand.

Mr. WILLANS said the need for such an arrangement as that fitted up by Captain Sankey and Mr. Andersen arose from the fact that dynamo makers had confidence in no measuring instruments except their own. They (Messrs. Willan and Robinson) formerly used Siemens' instruments, but the zero adjustment was troublesome, and only one person at a time could take the readings. With a spot of light two or more may take the reading, and this gave confidence to the parties interested. The average value of the quantities were those required, and Captain Sankey's method of taking the mean deflection, and then calibrating it, was, he thought, preferable to Mr. Crompton's zero method, or that of Prof. Ayrton, who relied on the spot always being in a definite place. The general result of the more accurate testing arrangements was to slightly lower the efficiencies. This, he said, was what might have been expected, for with imperfect instruments one was likely to take the highest of the several values obtained. Their experience was that most commercial instruments were unreliable when used in workshops near masses of iron, &c., hence the d'Arsonval form was adopted.

Captain SANKEY, in reply to Prof. Ayrton, said that the latter depended upon the accuracy of his scale, whilst they did not; hence the devices for obtaining proportionality were in their case unnecessary. By using a large rheostat they were able to employ a galvanometer of fairly high resistance with sufficient accuracy, and then their amperemeter galvanometer and their voltmeter galvanometer were interchangeable. The method of calibrating by using a known current was hardly possible in a workshop, for the copper deposit method was not convenient, and if another standard instrument be employed they would be depending on other people's calibrations. To avoid this, the method of checking and standardising described in the Paper was devised. To Mr. Evershed he pointed out that as the value of the mean deflection was determined immediately after every important test, the additional corrections he had referred to were eliminated. In designing the rheostats, they had taken care to put their potential wires at points where the flow was uniform.

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Mr. ANDERSEN said that, in calibrating the mean deflection, only the standard ohm and the standard cell were relied on. Ohms could be made so as to be very near the Board of Trade requirement of 1 part in 10,000. As regards cells, Mr. Swinburne seemed to be under too much apprehension about them. He himself knew from experience that they could be made up to agree very closely with the standard value, when once one had got the "knack" of doing it. He was glad to know that "spot watching" had a good chance of being largely used by engineers, for a good spot was far superior to any pointer. Referring to the design of d'Arsonval galvanometers, he said some of the points mentioned by Prof. Ayrton were good, but he did not agree with the system of winding them with platinoid. An instrument so wound was necessarily about 25 times less sensitive than one wound with copper. Curved pole pieces and freely-suspended coils were good; the latter he himself had used several years ago. Magnetic shunts he thought unsuitable for workshop use. A resistance box was better, for one could trust a person to use the proper plugs. The six scales on the roller he considered unnecessary, for only one scale was required and five other sets of figures.

The CHAIRMAN (Mr. A. Siemens) agreed with Mr. Trotter as to the great advance made in electrical measurement since the formation of the society. The paper now before the Institution was a proof that electrical engineering had now become a science, and he doubted whether any other profession could show such a record of progress made in so short a time.

THE LIGHTING OF THE CITY.

The following report of the proceedings at Tuesday's meeting of the Commissioners of Sewers is from the *City Press* of Wednesday.

On the Court proceeding to consider the letter received from the City of London Electric Lighting Company asking for an extension of time of at least one year for carrying out the public lighting of the City,

The CLERK said he had received a further letter from the Company to the effect that there appeared to be some misapprehension with regard to the object of the application. In asking for an extension of time, the Company did not wish to relax their efforts, but the object was to ask the Commissioners to recognise the preliminaries for commencing the work, and to grant (if necessary) further time to complete the work. There was no intention of delaying the work; on the contrary, it would be pushed forward. The Company reminded the Commissioners that some time had been taken up in getting the consent of the Commissioners and the Board of Trade to the necessary transfers; but as the final designs for the lamps had been approved by the Commissioners the work of lighting other main thoroughfares would be at once proceeded with. The installation at the Mansion House would be ready by the 11th inst., and the work of opening the streets would be undertaken without delay.

Mr. SAYER moved that this communication, with the previous letter, should be referred to the Streets Committee.

Mr. PANNELL, in seconding this, said he did not think the Commissioners could enter into a discussion on these letters unless the whole Court was in possession of certain information which was possessed only by a few members of the Streets Committee.

Mr. TRELOAR described the application as preposterous, and said if it was granted the Commissioners would be the laughing stock of the community. He earnestly hoped there would be no more dilly-dallying.

Mr. Deputy EDMESTON hoped it would not go forth that that was the general opinion of the Commissioners; at least, it was not his opinion. He thought there was a great deal to be said as to why the Commissioners should not hurry this question, or place any block in the way of the Company's undertaking.

Mr. MORTON declared that the whole difficulty had arisen through the promotion of companies. The Commissioners were told distinctly on inquiry that the lighting companies which secured the contracts were able to carry out these works. They were assured that they were dealing with *bonâ fide* companies which could carry out the undertakings, but it seemed to him that the contracts had been used for the promotion of companies. There was the Pioneer Company, and then there was a final transfer to another company, and between these transfers an enormous amount of profit had been made by someone. He knew it was done with the consent of the Commissioners, and the Streets Committee had been fooled, and would be fooled again. But the Commissioners had a weapon against these companies, namely, the £3,000 on deposit, which could be distributed among the ratepayers to repay them for the disappointment in not having the electric light, and the Commissioners could go further by annulling the contracts which had been entered into, and send all speculators and adventurers about their business. He thought the citizens would ultimately have the advantage if these contracts were annulled.

Mr. Deputy ROSE-INNES said the application was a manifest injustice, because one Company had come in and knocked the other companies out in consequence of the low price the Company in question had offered to supply the light at. He could not but feel grossly dissatisfied at the application. Mr. Deputy Rose-Innes then referred to what had been done by the Commissioners in electric lighting, when some years ago a sum of between £900 and £1,000 was spent in experiments. With regard to what had been said by Mr. Morton, there was another security which the Commissioners possessed, namely, the large quantity of capital which had been invested in the streets, and if the present Company was a thoroughly good and solvent Company with a good banking credit, they ought not to hesitate in expending more capital by putting on more men, and making a struggle to complete the contracts.

Mr. C. T. HARRIS said he warned the Court against giving the contracts to the companies in the first instance, because they were not electric lighting companies. In his opinion it would be a fortunate thing if these contracts were annulled, and he moved as an amendment that the communications should be referred to a committee consisting of the whole Court.

Mr. SMALLMAN seconded this.

Mr. MCCARTHY thought if the Court decided not to grant the extension the work would be done, and the best thing to be done was to tell the Company plainly so.

Mr. CLOUDSLEY supported the amendment.

Mr. SLY considered the members would fail in their duty if they did not insist upon the Company carrying out the terms of their contract.

Mr. HUDSON failed to see how it was that the City of London would benefit by any extension of time, and at the proper stage of the debate he would be prepared to move that none be given.

Mr. STANLEY said he attended the Court that day on behalf of the General Purposes Committee, the Corporation having undertaken to light the Mansion House by electricity, and the committee was naturally alarmed at the proposed extension of time. The gas lamps at the Mansion House were being utilised for the reception of the electric light, and if it was postponed there would be neither gas nor electric light in the Mansion House. He therefore asked the Court to assist the General Purposes Committee in this matter, and to issue orders for the supply of the current to the Mansion House at least. He had been informed by the Secretary of the Company that the twelve months might not be needed, but that some extension would be necessary in order to complete their installation. He thought it was useless to talk about cancelling the contracts, because what would become of the plant? but he considered the best course to pursue was to send the matter to the Streets Committee, in order that they might find out how much work had been completed by the Company.

Mr. BRIDGMAN thought that there was something more in the application than appeared before the Court.

Mr. Deputy BEDFORD expressed a wish that some member of the Court would shed a little light on this complicated question by a brief clear statement of the position of affairs. Having spoken of the manner in which the subject had been complicated by the transfer of contracts from one company to another, the Deputy said this had been done at the expense of the ratepayers. Anyone looking at the state of the work in the streets knew that it would be impossible for the Company to complete their contract by February next; yet if the Commissioners were going to cancel these contracts the streets would be left in a terrible state in regard to future efforts of street lighting. He suggested that if the Company wanted two or three months' extension they should have it, but that penalties should be imposed if the time granted was exceeded.

Mr. GREENWOOD supported the amendment.

Mr. PANNELL contended that it was of little moment whether the question was settled by the Streets Committee or a committee of the whole Court. He concurred with the suggestion made by Mr. Deputy Bedford as to the granting of a small extension. As to the financial condition of the Company in question, he reminded the members of the Court that it possessed a million of money wherewith to carry out the work.

Mr. TRELOAR said it seemed to him that Mr. Pannell had been a little misleading with regard to the Pioneer Company—or he believed it was called a syndicate. The chairman of that syndicate was the late Lord Mayor, and the syndicate had financed or finessed the undertaking—and apparently they made some money out of it or someone did. Mr. Deputy Bedford has asked for someone to make a clear and lucid statement of the position of affairs; and if the late Lord Mayor had been present, he would have been able to supply the information, and put the matter properly and squarely before the members. He regretted that the late Lord Mayor had not attended the meeting that day for this purpose. As to the petition he did not think that the Court should give any extension, and that they should give a straightforward answer.

The CHAIRMAN then put the amendment, which he declared to be lost. A division was demanded, with the result that 34 voted in favour of the amendment and 28 against; majority six.

Mr. WALLACE then moved, as a further amendment, that the terms of the contract should be adhered to.

The amendment was put to the vote, and the CHAIRMAN declared it was carried unanimously.

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THE ELECTRIC LIGHTING OF ST. PANCRAS.

At Tuesday's meeting of the London County Council the Finance Committee reported on the application from the Vestry of St. Pancras for sanction to borrow £60,000 for electric lighting works, to be repayable in 42 years. They had reported on the cost (£62,999) of the proposed works on November 17th, and recommended a loan of £56,300, repayable as to certain parts in varying periods of 5, 8, 15 and 30 years, such varying periods being fixed on the advice of the engineer, with reference to the probable life of the work on which the expenditure would be made. In consequence of the discussion which took place at the Council on November 17th they had seen a deputation from the Vestry, who had pointed out to them that the works as a whole would make up a permanent concern, and must, whenever necessary, be renewed from time to time out of the Vestry funds, so as to be kept always in good working order. They pointed out to the deputation that the Council was, under its present powers, precluded from granting loans for works for a longer period than 30 years, except for street improvements and bridges; but, while admitting this, they urged, in view of applications likely to be made by other parishes for loans to carry out similar works, that the Council should obtain statutory authority to grant loans spread over a period not exceeding 60 years. Under these circumstances the committee considered that it would be better for the Council to authorise the Vestry to borrow elsewhere than from the Council the sum of £60,000, leaving open the question of the Council's advancing this sum if Parliamentary authority was obtained for a longer period than 30 years. They recommended—(*a*) That the sanction of the Council be given under seal to the borrowing by the Vestry of St. Pancras of the sum of £60,000 towards defraying the cost of certain electric lighting works at a rate of interest not exceeding £4 per cent. per annum, and the principal being repaid by equal annual instalments within a period of 42 years from the date of the loan; (*b*) that the Council do apply to Parliament for power to make advances for electric lighting purposes to Vestries and other rating authorities within the county of London for periods not exceeding 60 years, and that it be referred to the Parliamentary Committee to take steps to obtain the necessary statutory authority for that purpose.

Mr. CAMPBELL said he would be the last to throw any obstruction in the way of so enterprising a parish as St. Pancras, but the duty of the Council with regard to these loans was to see that posterity was not unfairly burdened. The St. Pancras Vestry deserved the greatest credit for getting the Provisional Order to carry out their own electric lighting. He moved that the report be referred back to the committee for further consideration.

Mr. OSBORN supported Mr. Campbell's proposition. It seemed to him an extraordinary thing that they should take out of the rates sums of money to put up plant of very short life and spread their repayment over 42 years. Hitherto they had taken great care in granting money to local authorities to see that there was ample security for the money. In the case now before them they had none whatever. The parish of St. Pancras was starting with considerable doubt as to the success of the project, and they ought to remember the advances in electric lighting, which would involve alterations. In his opinion they ought not to go beyond 12 years, and certainly in no case ought they to go beyond 15.

Mr. CLARKE said he looked with alarm on the Council authorising loans for such a period on such perishable articles.

Mr. WESTACOTT reminded the Council that they were not agreeing to lend the St. Pancras Vestry the money; they were only authorising them to borrow it for a period not exceeding 42 years. He hoped the Council would encourage the Vestry of St. Pancras.

Lord LINGEN (the Chairman of the Finance Committee) said it was seldom that he appeared before the Council to advocate a long in preference to a short period of repayment. His own opinion was most strongly, as a rule, in favour of short periods. That doctrine had not always been readily welcomed there, and he hoped after the feeling which had been shown on that proposal the doctrine would receive more favour in future. They had told the applicants that with their present powers they could not lend to them for more than 30 years. It was impossible for the Council to shut its eyes to the fact that the example which St. Pancras set in that matter was an extremely important one. Parliament had expressed an opinion on the whole favourable—certainly not unfavourable—to the idea that the municipalities should undertake for themselves, and not leave to comparatively independent companies, such undertakings as involved the breaking up of the streets. That, on the whole, he thought was a sound policy. Supposing St. Pancras did not go into the open market to borrow this money, the only alternative was that they must go to Parliament, and he himself rather leaned to the idea that they should go to Parliament, because, if they considered the magnitude of London and the enormous importance of the lighting of it, as to its being done in the most efficient and economical manner, he thought it really was a question of Parliamentary magnitude. The Council, therefore, by adopting the recommendations of the Committee, did not commit themselves to any very dangerous precedent.

The amendment was rejected, and the recommendations of the Committee agreed to.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November* 20, 1891.

The Berliner Microphone Patent.—The electrical sensation of the hour is the issue of the long-delayed Berliner microphone patent. It is the one to which the Bell Company has been looking for a long time as a possible means of extending its monopoly on the expiry of the Bell patent in 1893, and the original application for which was filed as early as June 4, 1877. That application covered in a broad way the microphone transmitter. At about the same time (July 20, 1877) Edison took the field with the same invention, and within a few months the pair were in interference in the Patent Office. Berliner's claim was transferred to the American Bell Telephone Company, and Edison's, originally assigned to the Western Union Telegraph Company, was transferred by that organisation to the Bell Company, under the famous agreement whereby the two were to have the monopoly respectively of the telegraph and telephone business. There were other subsidiary interferences besides the main one which dragged its slow course along year after year in the Patent Office. Meanwhile, both Berliner and Edison, in conflict on the broad claim, were industriously getting out detail patents, all of which became the property of the American Bell Telephone Company. These claims were filed during the latter part of 1877 and the early part of 1878. In 1880 the notorious Daniel Drawbaugh filed an application for a patent covering the same general idea. That application never got so far as an interference with either Edison or Berliner, but was made a shuttlecock between the Patent Office and the Drawbaugh attorneys for 11 years. The main question in the Drawbaugh case was whether the application should not be barred out altogether on the ground that the Edison carbon transmitter had been in public use two years before the Drawbaugh application in 1880. After a long period of cross-fire, proceedings to determine this question of public use were brought against Drawbaugh in the Patent Office; and Commissioner Simonds finally rejected, on this ground, the Drawbaugh application on October 28th last. In the meantime the Berliner-Edison interference had been finally settled in favour of Berliner in 1886, but the claims lay dormant until it became necessary for the continuance of the monopoly to drag them out. Even had the Bell Company desired to get the patent out it was not possible under Patent Office procedure so long as the Drawbaugh application, which might go into interference with it, was before the Office; that disposed of, the Berliner patent was issued bearing date November 17, 1891, No. 463,569.

The most important claim is as follows:—

> The method of producing in a circuit electrical undulations similar in form to sound waves, by causing the sound waves to vary the pressure between electrodes in constant contact, so as to strengthen and weaken the contact and thereby increase and diminish the resistance of the circuit substantially as described.

The following disclaimer is made:—

> I do not claim that I am the first inventor of the art of transmitting vocal and other sounds telegraphically by causing electrical undulations similar in form to the sound waves accompanying said sounds. Neither do I claim that I am the first who caused such electrical undulations by varying the resistance of an electric circuit in which a current was passing.

The claim, it will be seen, is broad and methodic, and although the apparatus shown and described in the application is in a very rudimentary form, the wording of the claim is such as might be construed by a liberal judge into covering the microphone transmitter pretty thoroughly. The foreign patents issued to Berliner are not of so broad a character, being confined in the main to details, and hence may not invalidate the present patent by their expiration. A strong fight will probably be made, however, in the Courts, before the Bell Telephone Company is allowed to continue its obnoxious

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monopoly for another long term of years. The sentiment of the public and of the Courts will doubtless be against a broad interpretation of the Berliner claims, involving as it would 17 years of servitude to the Bell Telephone Company. The long delay of the claims in the Patent Office will influence their validity unfavourably, since it is only too evident that it was for the interest of the Bell Company to continue the interferences, both sides of which it owned, for the purpose of securing a patent of a later date. Of course the same reason is sufficient to account for the very slow progress of the Drawbaugh application, even supposing there was no collusion of any sort.

The immediate effect of the issue of the Berliner patent was a sharp rise in the stock of the Bell Telephone Company, which has been followed by a slight decline. The daily press is full of denunciations of the telephone monopoly, and there is every reason to believe that a most vigorous fight will be made if there is any attempt to enforce the Berliner patent.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *November* 28, 1891.

There is every likelihood of an electric railway being soon undertaken between Stockholm and Djursholm. A company holds a recent concession for an ordinary railway, and has now petitioned the Government that the concession may be so altered as to comprise electric traction. As soon as the necessary permission has been obtained the works will be commenced.

The Swedish State telephones have during October been used for 19,648 conversations on the interurban telephone lines, yielding receipts of 7,435kr., against a sum of 989kr. for the same month two years ago, and 1,962kr. for the same month last year, which affords a striking proof of the steady increase in the case of the telephone.

The Stockholm General Telephone Company does not see its way, it is understood, to avail itself of the permission to lay underground cables in the streets on the stipulated conditions, which the Company thinks would be ruinous. The Company has, therefore, in hand a plan involving the conversion of its entire system to a double-wire one with overhead cables.

It is on the whole marvellous how popular the telephone has become in Sweden, not only in the towns, but in poor and out-of-the-way country places. The Herjedale furnishes a striking example in this respect. In Sveg, a small place with only about 150 inhabitants, some 40 or 50 miles from the nearest railway station, the doctor, the chemist, the innkeeper, the tradesmen, and every farmer in the neighbourhood have telephonic connection, not only with the railway station but with two or three even more distant towns. They pay each 200kr., or £11, for the line ; 75kr. (£4. 3s.) for the telephone ; and 50kr. (£2. 15s.) fee for the first, and half that amount for subsequent years. There are tradesmen in the same district who have hardly more than 1,000kr. a year, and who have found it worth their while to invest in a telephone, the line of which has cost them 800kr., or nearly a whole year's income. It appears, too, that everybody finds it is well-spent money, and that they would not do without the telephone at any price.

The Budget for the Swedish State telegraphs during 1892 has recently been fixed. The calculated expenditure amounts to 1,325,000kr., which is a few thousand kroner more than the calculated expenditure for the current year.

A committee has been appointed in Sweden to look into and report upon questions bearing upon transmission of power by electricity, more especially as far as the prevention of accidents is concerned. The requisite regulations will be drawn up, and there can be no doubt that the transmission of power by electricity is coming to the fore in Sweden, where the many waterfalls furnish large quantities of power, which is at present barely utilised. Several large schemes are already under contemplation ; but I must reserve further mention of these for a future letter.

Projected Elevated Railway in Berlin.—The *Elektrotechnisches Echo* is informed that a settlement has been arrived at between the President of Police in Berlin, the Minister of Works, the Town Council, and Messrs. Siemens and Halske, with regard to building an elevated railway between the Zoological Gardens and the Warschauerstrasse.

CORRESPONDENCE.

PLATINOID *v.* COPPER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the discussion on Capt. Sankey's Paper at the Institution of Electrical Engineers, Prof. Ayrton raised an objection to the use of copper-wound d'Arsonval galvanometers for the purpose the authors used them, and said that a platinoid winding should always be used. The time being short, Capt. Sankey, in his reply, merely said that they preferred copper on account of its sensitiveness. Perhaps you will allow me to put the matter a little fuller in behalf of copper. Say you have one galvanometer P, wound with platinoid 100 turns, and R = 500. A similar galvanometer, C, wound with the same number of turns of copper of the same gauge, will be only 20ω ; the specific resistance of platinoid being approximately 25 times that of copper. It gives, therefore, for a given potential difference at its terminals, 25 times the deflection that P does ; which is extremely convenient when working low down.

At the same time, by adding in series with C a platinoid resistance of 480ω, you have a galvanometer which is absolutely identical with P, both in sensitiveness and resistance, and with a temperature coefficient only about $\frac{1}{480}$ per cent. higher. Surely a very low price to pay for having an instrument, when wanted for measuring small D · P's, twenty-five times as sensitive as the one all platinoid.

I have never had occasion to determine the temperature coefficient of platinoid in the slab, as used by Prof. Ayrton and at Thames Ditton, for current measurements, but should expect it to have a higher temperature coefficient than the comparatively small wire on a galvanometer, as platinoid wire shows a strong tendency to decrease in T.C. the finer it is drawn, so that the copper combination might be even better than the all platinoid one.—I am, &c.,

C. W. S. CRAWLEY.

16, Red Lion-street, Clerkenwell.

THE TRUE FUNCTION OF THE THOMSON AIR-BLAST.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your editorial note upon the Van Depoele reciprocating drill (*The Electrician*, November 6th, p. 2) you say, "Our correspondent says nothing about the sparking which might reasonably be expected at the commutator of the dynamo. The Thomson-Houston Company are probably equal to the occasion with some such heroic device as an air-blast."

The misconception as to the purpose of the air-blast on the Thomson-Houston three-coil arc dynamo is widespread, due largely to the unfortunate statement in Prof. Thompson's invaluable and generally most accurate volume on "Dynamo Electric Machinery," Third Edition, 1888, p. 245.

For authority Prof. Elihu Thomson, the designer of the machine, may be quoted as follows: "I called Mr. Milton E. Thompson's attention in regard to the blowing out of the spark as expressing an erroneous idea in relation to the machine. This he would find expressed in Silvanus P. Thompson's 'Dynamo Electric Machinery,' that the air blast in the Thomson-Houston three-coil machine is for the purpose of blowing out the spark. This is not at all the case, and never was, and the air-blast was introduced for no other purpose than to make it possible to run the machine steadily at high differences of potential with a commutator which could be freely oiled. It was found in the early experience with the machine that it was possible to construct a machine up to 12 to 15 arc lamps which would retain the normal working condition without flashing over, as it is called—short circuiting across the slots and the short circuit being carried around. But beyond that potential difference there was an imminent danger of its occurring, although a 25-light machine might run for half an hour or an hour and a-half without any flashing or short circuiting over. Of course the tendency to flash over increased with the difference in potential. Now, it was also desirable to run the commutator with a film of oil,

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to freely oil the machine; and when the commutator was freely oiled, the limiting potential which could exist without flashing over was much lower. Even a 10-light machine might flash readily if there was a good deal of oil on the commutator. In the early days men would oil the commutator. It was almost impossible to keep them from taking an oil-can and squirting on the commutator. . . . Another thing, the oil on the commutator, of course, diminished the wear; so that if there was any little roughening it was relieved a great deal from cutting and making copper dust around the commutator. . . . The reasoning used in getting the air-blast was this, that on the leaving of this segment there would be a small amount of current still fed from the segment to the brush, which would, as it were, tail off, and the sparks would be thicker at the brush and gradually thin out to a fine point and then stop. Then the segment would change polarity and go on to the other side. But, naturally, if the change of polarity was immediate on the cessation of that spark there might remain, as it were, from the spark, hot gas, which would enable the discharge to take place in the opposite direction, and that was a flash which would be carried over from the arc. My idea was simply to blow a cold blast of air, as it were, to drive that spark away and insert, no matter how thin, a layer of cold air before the reversal was accomplished, and in that way *to keep the insulation* of the machine. That process is found effective even with a three-coil commutator up to 3,500 or 4,000 volts, with the pressure, of course, slightly increased as we rise." (Discussion of Milton E. Thompson's "A Study of an Open Coil Arc Dynamo," A.I.E.E., May 21, 1891.)—I am, &c.,

J. Stanford Brown.

611, 612, Electric Exchange, New York,
November 20, 1891.

HISTORICAL NOTE ON TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Remembering that cause and effect are equivalent, it occurred to me that the ordinary action of a Ruhmkorff coil machine might be reversed, so that, instead of producing a secondary current of high voltage and small quantity from a primary of low voltage and large quantity, we might produce a current of low voltage and large quantity from a current of high voltage and small quantity.

The simplest way to do this seemed to me to be by the use of two exactly similar Ruhmkorff coil machines. Connect the thick primary coil of the first machine with the battery, and the thin secondary coil with the thin secondary coil of the second machine. Then I supposed that we should get from the thick primary coil of the second a current similar to that in the primary coil of the first machine.

I do not clearly recollect whether I tried the experiment, but I brought the subject in this form before an eminent physicist, still living. His reply, dated December 31, 1866, was as follows:—"Cause and effect are certainly equivalent, but in your experiment you employ only one part of the effect of the primary. Try what is the effect of simply lifting the hammer of your first coil, not allowing it to fall. If your galvanometer be sensitive, you will get *some* effect."

This reply was beside the point, and simply told me what I knew before, namely, the mere fact of induction. What I wanted to know was whether we could reproduce our primary current in the way I have described.

If I rightly understand the subject, what I then suggested, about 25 years ago, is exactly what is done now by the modern transformer, which is simply a sort of modified induction apparatus with a primary and a secondary coil, by means of which a current of high voltage and small quantity can be changed into one of low voltage and large quantity, or *vice versâ*, as expressed by the formula $E\ C = E_1\ C_1$.

In an interesting Paper on the Frankfort Electrical Exhibition (*Nature*, 1st October, 1891), it is stated that Deprez and Carpentier's suggestion of alternate-current transformers was first put forward in 1881, and that the transformer of Gaulard and Gibbs appeared in 1883. Dr. Walmsley ("Electricity in the Service of Man," p. 684) writes to the effect that so widespread was the conviction that an induction coil would only work in the direction of raising electromotive force, that a patent to use this instrument, so as to increase the quantity of the induced current (as compared with that of the inducing current), was refused as impossible by the United States Office in 1883.—I am, &c.,

Cardiff: 47, Park-place, Chas. T. Whitmell.
November 26, 1891.

AN IMPORTANT POINT OF LAW.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: At meetings of local authorities the question is from time to time raised whether members interested in gas undertakings are entitled to vote or take part in discussions upon electric lighting matters. It may be useful, therefore, to the electrical industry to know what the law on this subject is. Mr. Sydney Morse has had occasion to take counsel's opinion upon the point; and, as I have obtained the permission of his clients to publish the opinion (which he has obtained from Mr. R. S., now Mr. Justice, Wright), I enclose it herewith, and trust that its publication by you may help to prevent the continuance of the injustice which is now frequently done to electrical companies by representatives of the gas interest.—I am, &c.,

E. Garcke.

Albert-buildings, Queen Victoria-street, E.C.,
December 2, 1891.

OPINION.

The Urban Sanitary Authority of ——— is the Corporation acting by the Council (*see* Sec. 6 of the Public Health Act, 1875), and consequently the present question turns on the construction of Sec. 22, Sub-sec. 3, of the Municipal Corporations Act, 1882. In my opinion, those members of the Council who are shareholders in the Gas Company have a direct pecuniary interest in the question whether or not the Council shall give their consent to the application by the Electric Light Company for a license under 45 and 46 Vict., c. 56, sec. 3, and such members are not entitled to vote on the question or to take part in the discussion of it. No penalty is attached to a breach of Sec. 22 Sub-sec. 3, and all that can be done in order to prevent such members from voting will be to get some member of the Council to draw the attention of the Mayor to the fact that the votes in question ought not to be received, and will be invalid. *See* Rule 10 of the 2nd Schedule to the Municipal Corporations Act, 1882.

(Signed) R. S. Wright.

45 and 46 Vic., ch. 50, sec. 22.

3. A member of the Council shall not vote or take part in the discussion of any matter before the Council or the Committee in which he has directly or indirectly, by himself or by his partners, any pecuniary interest.

THE THEORY OF THE WIMSHURST MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In answer to Mr. Gray's letter, a proof of which you kindly sent me, I propose, in order not to protract to eternity this already long discussion, to go to the root of the matter and not to confine myself to mere questions of detail.

Prof. Thompson assumes that A_1 is positively electrified, and explains how this charge results in the negative electrification of the B sectors included in the quadrants I., and IV.; and he adds, "In the lower half of the machine similar actions are going on, with the result that the positive charges are brought to the left side of the machine by both discs, whilst negative charges are brought by both discs to the right side." This second part of the reactions is only possible if we allow either (i.) the primitive distribution supposed by Mr. Gray, or (ii.) the positive electrification of B_5 by the influence of A_1 across $\beta\beta_1$, the latter being to earth at the middle; this action is not possible. Prof. Thompson moreover declares that he does not bring in the diametrical conductors. There only remains the primitive electrification accepted by Mr. Gray, which is exactly what I said. Besides the objections urged by me in my last letter against this starting point, I will show you that it explains nothing. It is, in fact, quite as logical to allow that an analogous distribution exists on the second plate; there would, therefore, be no need to find a

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theory for this curious machine because it would work by itself.

We must, I think, reject every hypothesis in which the original charge, that is to say, the auto-excitation, intervenes, so long as we do not know the exact source of it. Auto-excitation is not an essential part of the action of the machine, since the machine requires in certain cases to be excited. It is this more general case that we must consider.

Prof. Thompson does not explain the augmentation of the charges. As to Mr. Gray, I must recall his own words to his mind in order to show the great difference which exists between the theory he gave in his excellent book and that which he now gives. After having explained how the distribution is effected, Mr. Gray adds, "The two halves of B now in turn act as field-plates to induce charges on the carriers A of the disc A; and a little consideration will show that, *owing to the motion of this latter disc, the charges originally upon it will be increased by this action.*"

There is a wide difference between this theory and the one which I have given. As I remarked in *La Lumière Electrique* of October 10th, it follows from the passage underlined that at that time Mr. Gray admitted that the charges are accumulated on the carriers, fresh charges being added to the old ones as in ordinary multipliers, which is not possible because the same sector is in turn field plate and carrier, and in one complete revolution takes a positive charge, is put to earth, takes a negative charge, is again put to earth, takes a fresh positive charge.

Mr. Gray adds, "My theory was not intended to show how the final distribution arises from the primitive distribution." That is the very fault I complain of in the majority of theories put forth; the growth of the charges—we are in accord on that point now, Mr. Gray and I—being only the result of distribution effected; if we do not show how this distribution of electricity on the plates is caused, the action of the machine is not explained at all.

I have endeavoured, by studying the electrical reactions which are produced, to ascertain what is the *process* of this distribution; the theory which I gave, is it correct? It seemed so to me when I published it, though the objections which are raised against it would tend to make me doubt its accuracy. However, I would ask Mr. Gray to note the following:—

1. I not only claim the theory of the distribution as pointed out by me, but also the theory of the growth of the charges which, as I have already explained, I was the first to give.

2. It is no reason because one has not up to the present brought in the lateral inductive action of the carriers that it does not exist. By reason of the earthing of the sector under consideration there must be produced a sort of condenser action which gives a certain importance to this lateral induction; and feeble as it may be when compared with the action of the opposite sectors on the two plates, it is none the less sufficient to explain the excitation of a reciprocal action machine.

3. The action on sector A_7 pointed out by Mr. Gray cannot have the importance which he attributes to it. In fact, a careful study of my theory will show that I only bring in the lateral induction at the beginning, that is to say, when all the sectors are not as yet electrified; this lateral induction is, therefore, produced in the way I said. When all the sectors are electrified the symmetrical actions neutralize each other, and there only remain those of the opposite plates. Before the normal *régime* is established the lateral induction may, as Mr. Gray says, tend to diminish the action of the opposite carriers, but it is always much less than their action, and soon, owing to the multiplication of the charges, each sector will acquire its maximum charge and the normal *régime* will be established.

I thank you for having so hospitably opened your columns to me, and, as a justification of the length of this discussion, I can only point to the conclusions of my learned opponent.
—I am, &c.,
G. PELLISSIER.

Paris: November 26, 1891.

LEGAL INTELLIGENCE.

Savory and Moore v. London Electric Supply Corporation.

In the Chancery Division of the High Court of Justice, yesterday, the case of Savory and Moore *v.* London Electric Supply Corporation again came before Mr. Justice Kekewich. This was an action brought by the well-known firm of chemists in Bond-street, to restrain the defendants from carrying on their business in a manner likely to cause injury to the plaintiffs' premises. The case came before his Lordship a few months since, when it was adjourned in order that certain alterations should be effected by the defendants to prevent the possibility of any danger arising to the plaintiffs' premises.

Mr. HAMILTON, on behalf of the defendants, said he was not anxious that the case should come on before the whole of the alterations had been effected.

His LORDSHIP said he understood that the plaintiffs would be satisfied if an undertaking were given that no injury should be inflicted upon them by the defendants' works.

Mr. WARMINGTON, Q.C., for the plaintiffs, said that would hardly do. What the plaintiffs required was some kind of relief put into a distinct form, as they had a reasonable apprehension of injury.

Mr. HAMILTON, at the request of his Lordship, called Dr. Fleming and Major Waller, Manager of the defendants' Company, who gave evidence with the view of showing that since the case was before his Lordship a few months since, the defendants had taken steps to prevent any possible danger arising to the plaintiffs.

His LORDSHIP reserved his judgment until he had had an opportunity of reading over the evidence given on the last occasion.

Anglo-American Brush Electric Light Corporation v. King Brown and Co.

This appeal from the judgment of the First Division of the Court of Session, Edinburgh, revoking the Brush compound winding patent, came before the House of Lords yesterday. After hearing the Attorney-General on behalf of the appellants, the case was adjourned. Owing to the pressure on our space we are compelled to hold over our full report of the proceedings till next week.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS INVITED.—Our advertisement columns contain an announcement that the Town Council of Tiverton are prepared to receive offers from persons or companies for the transfer of the powers under the Provisional Orders obtained from the Board of Trade. Further information may be obtained from Mr. J. Siddalls, the borough engineer, Town Hall, Tiverton, and tenders must be sent in to Mr. C. Marshall Hole, town clerk, on or before January 1, 1892.

——— The Corporation of Worcester are desirous of receiving tenders with plans and specifications for constructing works for the supply of electricity to the central portion of the city. Tenders are to be delivered to Mr. Samuel Southall, the town clerk, at his office, Guildhall, Worcester, on or before February 14, 1892. Further particulars appear in our advertisement columns.

——— The Bournemouth Town Council invite tenders for lighting by electricity the pier, pleasure gardens and municipal buildings. Full particulars, forms of tender, and plans can be obtained of the borough engineer and surveyor, Mr. F. W. Lacey, and tenders are to be sent to the Town Clerk, Mr. J. Druitt, jun., by December 24th.

——— The North-Eastern Railway Company desire tenders for the supply, during the six months ended June 30, 1892, of telegraph apparatus and telegraph wire and line stores. Forms of tender may be obtained of Mr. Graves, Telegraph Department, York, and tenders must reach the Secretary, at York, by noon on Tuesday next, the 8th inst.

——— The Township of Galatz (Roumania) is desirous of granting a concession for the lighting of the town of Galatz by gas and electricity, and any person willing to undertake the business can see or procure at the Mayoralty the plan of the town and the terms and conditions. Tenders may be sent in up to January 20 (February 1), 1892, when the adjudication will take place.

CHRISTIANIA.—The contract for installing the central electric supply station has been given to Messrs. Schuckert and Co., of Nuremberg. The cost is estimated, according to a Reuter's telegram, at about £34,000.

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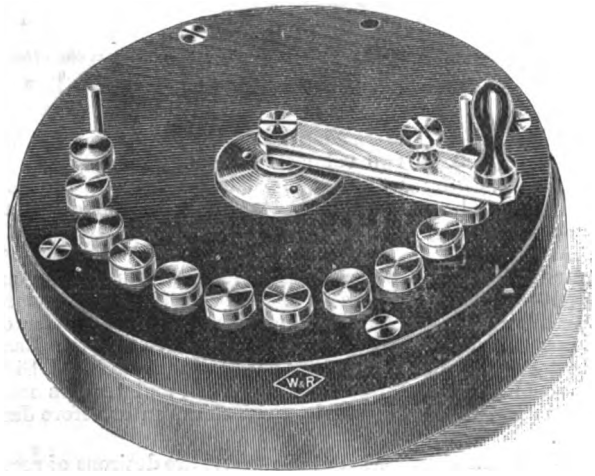
MESSRS. MOODY AND ANDREAE.—Mr. W. Andreae having withdrawn from his partnership in this firm, the name thereof has been changed to that of Moody Brothers. Messrs. Moody Brothers announce that they have taken over the stock and business premises of the late firm, and will execute all orders now in hand, and will continue to carry on the business as heretofore. Messrs. Moody Brothers are authorised to collect and give receipts for all money owing to the late firm, and they will also settle all the outstanding debts and liabilities.

——— We are informed by Mr. Walter Andreae that he is commencing business at 47A, Lower Belgrave-street, London, S.W., and will there carry on business, under the style of Walter Andreae and Co., as electrical engineers.

NEW FIRM.—We hear that Mr. Smeeton and Mr. Page, both of whom have been some years with the General Electric Company, have entered into partnership, trading as Messrs. Smeeton and Page, 63, Queen Victoria-street, E.C. Mr. Smeeton was pupil with Messrs. Goolden and Trotter, and since has been engineer to the General Electric Company on their foreign installations. Mr. Page was manager of the same firm's supply department.

BLYTH, NORTHUMBERLAND.—Messrs. Sanderson and Co. have recently taken over from Messrs. Nicholson and Jennings their contract for lighting the town of Blyth, Northumberland. We understand that Messrs. Sanderson and Co. have also established themselves as electrical engineers, &c., at High Quay.

MESSRS. HOWARD FARRAR AND CO.—The partnership between S. H. Farrar, G. Farrar, and J. P. Farrar, trading as above, has lapsed by effluxion of time. In future the Transvaal branch of the business will be carried on by S. H. and G. Farrar, and the colonial branches at Port Elizabeth and East London by J. P. Farrar. In both cases the present style of the firm will be retained. The London business has been transferred to Mr. F. A. Robinson, who has managed the same for some years, and will be carried on under the style of Messrs. F. A. Robinson and Co., Mr. Robinson acting as English agent for the Transvaal and Colonial houses. He will also liquidate the current business for Messrs. H. Farrar and Co., of London.



THE ELECTRICAL EXHIBITION AT ST. PETERSBURG.—In reference to our Note in a previous issue of *The Electrician*, the date of the opening of this Exhibition was given according to the Greek calendar, the date according to the Gregorian calendar would be the 25th December.

THE KRASNAPOLSKY WINTER GARDEN.—This elaborately decorated building has been lighted throughout by electricity, more than 1,500 incandescent lamps and 4 arc lamps being installed. The generating plant consists of three 80 H.P. engines driving three Crompton compound-wound dynamos, each capable of supplying 380 amperes at 110 volts. The installation has been carried out under the direction of Mr. G. E. Hartmans.

FYFE-MAIN ELECTRIC LIGHTING COMPANY.—This Company have successfully installed the electric light at the new premises of the *Field*, the *Queen*, and the *Law Times*, in Bream's-buildings, Chancery-lane, where two "Castle" dynamos generate the current for nine 15-ampere arc lamps in parallel, and more than a thousand incandescent lamps of 16, 32, 50, and 100 candle-power.

TEN-WAY SWITCHES.—Messrs. Woodhouse and Rawson United (Limited), of 88, Queen Victoria-street, E.C., are stocking switches of the type shown in the illustration. These may be had either 12 or 20-way, and are mounted on slate bases, neatly fitted into wooden frames. They are carefully designed, and no doubt will be much in demand.

S. Z. DE FERRANTI (LIMITED).—The *employés* of this firm held their annual dinner at the Wool Exchange Restaurant, Coleman-street, on Saturday evening last, when an exceptionally pleasant evening was spent by the men and their guests. Mr. Kilgour, the foreman, was in the chair, and was supported by Mr. Pascoe. After the usual loyal toasts, the Chairman proposed the health of the firm, and Mr. Ferranti, in replying, referred to the position which the electrical industry had now attained, and the fact of their having been so actively engaged at the inception of it should give them something to look back upon in years to come with considerable pleasure. The electric light particularly had passed through serious difficulties, both legislative as well as financial, but now that it had got free of this he predicted an extension upon which it was hardly possible to speculate at present.

ELECTRICAL TANNING.—A pamphlet containing a considerable number of experts' reports on the Groth process, a reprint of the Paper read before the Society of Chemical Industry, and a report of the trial of the British Tanning Company *v.* Groth, has been issued by Mr. L. A. Groth, of 3, Tokenhouse-buildings.

WOODHOUSE AND RAWSON UNITED (LIMITED).—This firm are issuing Section 8 of their catalogue. This section deals with electrical machinery and apparatus connected therewith, and contains illustrated particulars and prices of electric cranes (fixed and portable), capstans, winches, hoists, drills, ore separators, tools, lathes, drilling machines, welders, &c.

C. AND C. MOTOR PATENTS.—Messrs. Shippey Bros. write that it is announced in the trade that the Pilson Electric Company have secured an exclusive licence to manufacture and supply the Curtis, Crocker, and Wheeler electric motors and pumps for England and France. These motors are sold in Europe under the various trade marks of the C. and C., C. and W., and Standard systems.

MESSRS. J. E. H. GORDON AND COMPANY (LIMITED).—We learn that this firm will have completed their Larne installation shortly, and that the Bray installation is making very satisfactory progress; the latter installation is somewhat similar to that at Carlow, water-power being used with auxiliary steam. The actual number of lights at Larne is 4,000, with an ultimate 8,000; at Bray 10,000, with an ultimate 20,000.

ALTERION COMPANY (LIMITED).—A resolution was passed at a meeting held on November 10th that this Company, carrying on business as electrical engineers, at 20, Mount Stuart-square, Bute Docks, Cardiff, be voluntarily wound up, and that Mr. John Tellefsen be liquidator.

NEW COMPANIES, STATUTORY RETURNS, &c.

CONNELLY MOTOR COMPANY (LIMITED).—This Company was registered on November 23, 1891, with a capital of £70,000, in £1 shares, by Wynne, Holme, and Wynne, 40, Chancery-lane, W.C. The objects are to purchase or acquire, and to work, use, or sell any patents, and licences under patents, and any other property whatever, including therein any tramways and statutory or other powers to make tramways, and the business of any company, firm, or person relating to the construction, equipment, or working of tramways, or the manufacture of gas, oil, or other motors and machinery for use on tramways.

FREEMAN'S (LIMITED).—Registered by Bonner, Wright, Thompson, and Co., Ingram House, 165, Fenchurch-street, E.C., with a capital of £50,000, in £10 shares. Objects: To carry on, in all their respective branches, the businesses of builders and contractors, the general business of an electric light, heat and power supply company, &c.

RICHARD HILL AND CO. (LIMITED).—This Company was registered on November 26, 1891, with a capital of £50,000, in £10 shares, by Waterlow and Sons (Limited), London-wall, E.C. The objects are to acquire and carry on the business of iron and steel manufacturers, steel converters, general engineers, machinists, rollers of iron and steel for wire rods, bars, hoops, rivets, or plates, smiths, fitters, &c., carried on by Richard Hill at the Newport Rolling Mills and the Marsh Wire Works, at Middlesbrough, Yorkshire, under the style of "Richard Hill and Co." Registered office: Middlesbrough, Yorkshire.

KITTO CYCLE COMPANY (LIMITED).—This Company was registered on the 24th ult., with a capital of £20,000, in £1 shares, by Sir Joseph Causton and Sons, 9, Eastcheap, E.C. The objects are to carry on the business of manufacturers of cycles generally, and to carry on the business of electrical engineers and manufacturers of and dealers in machinery and apparatus relating to the production of electric force and power; to generate, accumulate, distribute, and supply electricity; and to construct and lay down all necessary cables, wires, lines, accumulators, lamps, and works. The first Directors are J. Willoughby, G. F. Youlton, W. H. Jennings, and W. H. Kitto (Managing Director), all of Plymouth. Registered office: 197, Union-street, Plymouth.

E. M. MALLETT AND CO. (LIMITED).—This Company was registered on November 24, 1891, with a capital of £12,000, in £1 shares, by E. M. Mallett, 1, Gresham-buildings, E.C. The objects are to enter into an agreement with E. M. Mallett and Co. for the acquisition of certain contracts, and to carry on the business of mechanical engineers, smelters, founders, workers in metal and clay, &c. There will be no Board of Directors, but for seven years the Company will be conducted by E. M. Mallett and J. Luttman, Managing Directors.

MILLER AND CO. (LIMITED).—This Company has been registered in Scotland, with a capital of £100,000, in £5 shares, to acquire and carry on the business of Miller and Co., engineers and ironfounders, Vulcan Foundry, Coatbridge.

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NATIONAL TELEGRAPH WORKS COMPANY (LIMITED).—This Company was registered on November 27, 1891, with a capital of £5,000, divided into 990 ordinary shares of £5 each and 50 founders' shares of £1 each, by A. P. Honeyman, 9 Bennett's Hill, Birmingham. The objects are to enter into an agreement with Joseph S. Lewis to carry on the business of manufacturers, or merchants of, or contractors for, pressed-steel, iron, or other metal; to carry on business as electrical engineers and contractors, and manufacturers of electrical appliances, insulated wires, cables, insulating materials, and other apparatus, materials and things required for or capable of being used in connection with electricity or other similar work; and to supply, equip, maintain, work, hire, let, sell, and deal in all apparatus and materials used in connection with electrical engineering. The number of Directors is not to be less than two nor more than six, the first being J. S. Lewis, of The Swifts, Yardley, near Birmingham (telegraph engineer), and A. H. Church, 242, Frederick-road, Aston Park, near Birmingham (electrical engineer). Qualification, 50 ordinary or 1 founders' share. Remuneration as fixed at the general meeting.

PATENT ELECTRO-MAGNETIC SYNDICATE (LIMITED).—This Company was registered on November 26, 1891, with a capital of £25,000, in £1 shares, by W. Beck, 2, East India-avenue, E.C. The objects are to acquire the interest in the invention relating to improvements in electrical appliances, for which W. R. May, of St. Paul's-road, Canonbury, has obtained provisional protection, and which is numbered 12,150 of 1891, together with all the patents, privileges, or advantages, now held or to be acquired by him; to adopt certain agreements for the above purpose; and to carry on the manufacture and sale of electrical or magnetic movements or timepieces generally; and the business of engineers, machinists, merchants, and dealers.

WM. ROBINSON AND CO. (LIMITED).—This Company was registered on November 28, 1891, with a capital of £5,000, in £10 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are to acquire the business carried on by A. H. Kreuser, at Wolverhampton; and to carry on the business (amongst others) of founders, wire drawers, tube makers, galvanisers, electro-platers, &c.

W. G. SKELTON, CORBITT, AND CO. (LIMITED).—This Company was registered on November 24, 1891, with a capital of £20,000, in £10 shares, by Pilgrim and Phillips, 17, Coleman-street, E.C. The objects are to acquire and carry on the businesses of iron and brass founders, steel makers, &c., by W. G. Skelton and Co., at Sheffield, and by William Corbitt and Co. (Limited), at Rotherham, Yorks. Registered office: Sheffield Grate Works, Rotherham, Yorks.

WADDLE FOUNDRY COMPANY (LIMITED).—This Company was registered on November 26, 1891, with a capital of £5,000, in £50 shares, to acquire and work the Penrhos Foundry, Llanelly, Carnarvon, carried on by M. R. Waddle; and to carry on the business of mechanical engineers, machine, and engineering tool makers, boiler makers, iron and brass founders, chemical manufacturers, &c. Registered by Andrew Wood and Co., 8, Great James-street, Bedford-row, W.C.

HENRY WALKER AND SON (LIMITED).—This Company was registered on November 28, 1891, with a capital of £50,000, in £5 shares, by T. W. Rossiter, 7, Ely-place, E.C. The objects are to acquire and carry on the business of ironfounders and ironmongers, carried on by H. Walker and J. G. Walker, at Gallowgate Ironworks, and 55, Westgate-road, Newcastle-upon-Tyne; and to carry on the business of heating, ventilating, manufacturing, electrical, and general engineers, plumbers, gasfitters, iron and brass founders, &c.

WINTERBOTTOM BOOK CLOTH COMPANY (LIMITED).—The objects of this Company, registered with a capital of £800,000, include the carrying on of the business of electrical and mechanical engineers.

CROMPTON AND CO. (LIMITED).—The following was filed on November 17, 1891:—At an extraordinary general meeting of the members of Crompton and Co. (Limited), duly convened and holden at the registered offices of the Company, Mansion House-buildings, in the City of London, on Tuesday, November 3, 1891, the following resolution was unanimously passed. [See *The Electrician*, Nov. 6, p. 20.] The usual forms for such increase were also filed on November 17, 1891. The above Company was registered on July 30, 1888, with a capital of £140,000, divided into 20,000 7 per cent. preference and 8,000 ordinary shares of £5 each. At the time of the statutory return, December 19, 1888, 15,576 preference shares had been taken up, and upon these £59,029. 10s. (including £3,629. 10s. payments in full) had been paid, leaving £2,988. 10s. unpaid. At the date of the last return all the shares had been taken up, the full amounts called on the preference, and, with the exception of £20, paid. The ordinary shares were issued to J. F. Allright (2,432) and R. E. B. Crompton (5,563) as fully paid. Office: Mansion House-buildings, E.C.

ELECTRICAL INVENTIONS COMPANY (LIMITED).—The above-named Company was registered on September 18, 1891, with a capital of £35,000, in £1 shares, filed on November 28, 1891. Its first registered office is situated at 57, Moorgate-street, London, E.C.

EUROPEAN SIMS-EDISON ELECTRICAL TORPEDO COMPANY (LIMITED).—An agreement made July 3, 1891 (and filed on November 25, 1891), between the Sims-Edison Electrical Torpedo Company (called the Sims-Edison Company), incorporated under the laws of the State of New York, of the first part, and the above Company of the second part, states that, whereas the former Company is the exclusive owner of certain inventions and improvements in electrical torpedoes, for which patents have been granted in England, France, Belgium, Luxembourg, Austria, and Italy, and whereas the Government of the United States of America have purchased eleven of the said electrical torpedoes for $125,000, and have ordered more; and whereas the Sims-Edison Company is desirous of disposing of all its rights to the said invention obtained or obtainable in Europe, India, Burmah, and the British Colonies; and since the European Company has been registered with a share capital of £210,000, divided into 10,000 £20 and 1,000 £1 shares; it is therefore agreed that the Sims-Edison Company shall sell and convey to the European Company the letters patent granted in England, Nos. 2,614 of 1883 and 439 of 1891; France, Nos. 169,446 of 1885 and 210,941 of 1891; Belgium, No. 69,212 of 1885 and one pending for 1891 Austria, No. 21,671 of 1885 and one pending for 1891; Luxembourg, dated June 11, 1885, and No. 1,401 of January 22, 1891; and Italy, No. 83, volume 57, of January 22, 1891; and all letters patent which may be obtained; and in full consideration the sum of £175,000, payable £18,000 in cash, and the remainder in fully-paid-up ordinary shares in the purchasing Company, to be allotted to the vendors or their nominees.

A supplementary agreement of July 28, 1891 (and filed on November 25th) fixed the purchase consideration as follows:—£18,000 in cash, as heretofore, £66,660 by the allotment of 3,333 fully-paid ordinary shares, to be numbered 8 to 3,340 inclusive, and the remainder in cash or fully-paid shares, at the option of the European Company.

An agreement, made August 17, 1891 (filed on November 25, 1891) supplemental to the above, states that whereas £800 in cash had been paid to the Sims-Edison Company, as part payment of the £175,000, and it had been proposed to pay a further sum of £2,200, it was agreed that within seven days from the date of the agreement the £2,200 should be paid to the vendor Company, and that the latter Company should hand over the patterns, moulds, and designs necessary for the commencement of the manufacture of the electrical torpedoes, and that Mr. W. Scott Sims should forthwith proceed to England to superintend the work.

An agreement dated August 24, 1891 (filed also on November 25th), determines that since the Sims-Edison Company are desirous that the manufacture of lifeboats under the above patents, in England, should be commenced, and that orders should be given by the European Company for the construction of a lifeboat combining the principle of the patents, the European Company, therefore, shall give orders for the construction of such a lifeboat, under the superintendence of Mr. W. Scott Sims, or another engineer of the Company, and that in consideration of the said undertaking the purchase price shall be reduced by £25,000.

An agreement made November 26, 1891 (and filed on the 28th following) states that since £3,000 in cash has been paid and 3,333 fully-paid ordinary shares have been allotted to the vendor Company, acting under the power given them, the European Company determine that the remainder of the reduced purchase consideration shall be fully satisfied by the allotment of 4,017 fully-paid ordinary shares to the vendor Company, these shares to be numbered 3,341 to 7,357 inclusive.

GLOBE ELECTRIC COMPANY (LIMITED).—The first registered office of the above-named Company, which was registered on November 4, 1891 with a capital of £10,000, in £1 shares, is situated at 36, Great James-street, Bedford-row, London, W.C. (Filed on November 28, 1891.)

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—Our advertisement columns announce that the Directors of this Company have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended September 30th last, and payable on the 21st inst. The books of the Company will be closed from the 14th to the 19th inst., both days inclusive.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts of this Company for the week ended November 29th amounted to £806; aggregate receipts for half-year to date, £15,943.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of November were £3,200, as compared with £3,193 in the corresponding month of last year.

DAN RYLANDS (LIMITED).—This Company, well known as the makers of glass-lined tubing for electrical purposes, have just placed on the market a further issue of 16,000 cumulative preference shares of £5 each, at a premium of £1 per share, and 6,000 ordinary shares of £5 each, at a premium of £5 per share.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment on January 14th next of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum on the preference shares of the Company, for the quarter ending December 31st; and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income tax, in respect of profits for the quarter ended September 30th. The transfer books of the Company will be closed from January 7th to 14th, both days inclusive. The traffic receipts of this Company for the month of November, 1891, amounted to £60,053, against £58,975 in the corresponding period of 1890, being an increase of £1,078.

EASTERN EXTENSION TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for November amounted to £40,686, as against £44,742 in the corresponding period of last year, showing a decrease of £4,056.

ELECTRIC INSTALLATION AND MAINTENANCE COMPANY (LIMITED).—An extraordinary general meeting of this Company was held yesterday (Thursday) at the registered offices, 4, Great Winchester-street, London, E.C., when the subjoined resolutions were proposed:—1. That the name of the Company be changed from the "Electric Installation and Maintenance Company (Limited)" to the "Crystal Palace District Electric Supply Company (Limited)." 2. That each of the existing £10 shares be divided into ten £1 shares. 3. That the existing Articles of Association of the Company be cancelled, and that the fresh articles (which can be inspected at the Company's offices, or at the offices of the solicitors, Messrs. Pyke and Voules, 85, Gracechurch-street, E.C.) be substituted therefor. The resolutions were passed unanimously, and will be sub-

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mitted for confirmation as special resolutions to a second extraordinary meeting, to be held on Saturday, the 19th inst. The following resolution was also passed, and will not require confirmation:—That the remuneration of the Directors for their services up to December 25th next be fixed in accordance with Article 83.

HALIFAX AND BERMUDAS CABLE COMPANY (LIMITED).—*The Statist* of November 28th contains an article calling attention to the position of this Company, with special reference to a prospectus which is being issued by a firm of circular addressers, &c., offering small parcels of the Company's Four and a-Half per Cent. Bonds, at £106 for each £100 debenture. *The Statist* particularly takes exception to the manner in which these bonds are offered to the public, and to some of the statements made in the prospectus. There is no indication that the prospectus is issued by the authority of the Company.

SHIPPEY BROTHERS (LIMITED).—We are informed that the bulk of the shares recently placed on the market in this Company have been purchased by Messrs. Gwynne and Co., Engineers, of Essex-street Works, Strand.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the half-month to November 30th were £2,333 as compared with £2,865 in the corresponding period of last year showing a decrease of £532.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Nov. 25.		Price Wednesday, Dec. 2.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Dec. 2.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/6	Anglo-American	48½	49½	49	50	5 1 0	Jan., Apr., July, Oct	49	..
£2,849,510	Stock	25/0	Do. Preferred	86½	87½	87	88	5 16 8	" "	87¾	87
£2,849,510	Stock	5/0	Do. Deferred	12	12½	12	12¼	..	" "	12¼	12
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July ..	..	..
130,000	£10	5/0	Brazilian Submarine	10½	11	10¾	11¼	7 2 3	Mar., June, Oct., Dec.	11 3/16	10⅞
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July ..	100¼	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	140	145	145	148	4 14 7	April and October ..	147½	144
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	16	17	16	17	5 17 8	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3¼	3⅜	3¼	3⅜	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9½	10½	9¼	10¼	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10¾	11	10¾	11	6 7 3	Jan., Apr., July, Oct.	11	10⅞
400,000	10	2/6	Eastern	14	14½	14	14¼	4 11 3	" "	14 3/16	14 1/16
70,000	10	6%	Do. 6 per Cent. Preference	14⅜	15½	14⅜	15½	3 18 8	" "	15¼	14⅜
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	109¼	107½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅞	15⅛	15	15¼	4 12 7	Jan., Apr., July, Oct.	15 3/16	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107	110	107	110	3 12 9	February & August	110	107½
£78,300	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	102	105	102	105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	98	101	98	101	3 19 3	Febuary and August	98½	..
180,227	10	2/0	Globe Telegraph and Trust	9⅝	9⅞	9⅝	9⅞	5 8 10	Jan., Apr., July, Oct.	9⅝	9⅜
180,042	10	6%	Do. 6 per Cent. Preference	14⅝	14⅞	14⅝	14⅞	4 0 8	" "	14⅝	14⅜
150,000	10	5/0	Great Northern	18½	19	18⅝	19	4 9 6	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	42¼	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	7¾	8¼	7¾	8¼	4 16 11	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	117	122	117	122	4 18 4	" "	..	..
15,609	10	6/0	West African Telegraph	7½	8½	7½	8½	5 17 8	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	96	99	97	100	5 0 0	March & September	98½	98
30,000	10	2/0	West Coast of America	3	4	3	4	..	January and July ..	3⅜	..
£150,000	100	8%	Do. Debentures 8% 1902	97	102	97	102	7 16 10	June and December	..	..
88,321	10	1/0	West India and Panama xd	1½	1⅝	1½	1⅝	..	" "	1 1/16	..
34,563	10	6%	Do. 6 per Cent. 1st Preference xd	8⅞	9¼	9	9¼	6 6 4	May and November	9⅛	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref. xd	7⅞	8½	7⅞	8½	7 1 2	" "	7⅞	..
67,007	15	6 0	Western and Brazilian xd	10	10½	10	10½	7 2 10	" "	10½	9⅞
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred xd	6½	7	6¼	6⅞	5 7 3	" "	6⅞	6⅜
30,364	7½	7/6	Do. 5 per Cent. Deferred	3⅞	4¼	3⅞	4¼	..	" "	4¼	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance.	1/16	1/8	1/8	1/4	8 7 7	May and November	1/8	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16	1/8	1/16	1/8	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅜	4⅝	4⅜	4⅝	6 9 9	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13	12½	13	4 12 4	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Prf. (£10 pd or fully pd)	12	13	12	13	3 14 1	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	107	109	107	109	4 2 7	January and July ..	108¾	108
58,000	5	1/0	United River Plate	1	2	1	2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£6 paid)	4	4¼	4½	5½	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
8,332	£5	..	House to House Electric	4½	5	4½	5	..	..	..	..
30,000	£5	3½	Liverpool Electric Supply (£3 paid)	2¾	2⅞	2¾	2⅞	..	..	..	..
10,000	£5	3½	Do. (fully paid)	4⅞	5⅛	4⅞	5⅛	..	..	..	..
111,000	5	..	London Electric Supply	1⅛	1⅜	1⅛	1⅜	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	10	10⅛	9¾	10¼	..	..	10⅜	10⅛
6,318	10	..	Notting Hill Electric Lighting (fully paid)	6	7	6	7	..	..	6⅞	6½
18,680	£5	3/6	St. James' and Pall Mall	8¾	9¼	8¾	9¼	..	..	9 3/16	8¾
7,900	£5	7%	Do. 7% Preference	7¼	7½	7	7½	..	..	7⅛	7¼
42,853	5	..	Westminster Electric Supply (£5 paid)	6¼	6¾	6½	6¾	..	..	6⅝	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/8	Brush Electrical Engineering	3⅜	3⅝	3	3¼	5 10 10	..	3⅜	3 1/16
69,996	2	6%	Do. 6 per Cent. Preference	2¼	2⅜	2	2¼	5 6 8	..	2 1/16	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5	5½	5½	5¾	6 1 9	January and July ..	5 1/16	5⅜
17,130	5	17½*	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	6%	Electric Construction	6¾	7¼	6½	7	..	—	7 1/16	6¾
70,000	2	10/0	Elmore's Patent Copper Depositing	2¾	3	3¼	3½	..	—	3 1/16	2 15/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20½	21½	20½	21½	4 15 3	February & August	21	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	103	105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	6	7	5	6	..	..	..	..
11,334	£10	8/0	Do. Preference	8⅞	9½	8¾	9½	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛	⅜	⅛	⅜	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid) xd	4¼	4⅜	4¼	4⅜	8 2 0	May and November	4⅜	4 1/16
36,250	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July.....	43	42¾
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July ..	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2¼	2⅜	2¼	2⅜	15 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	3⅜	3⅝	3⅜	3⅝	10 0 0	..	..	..
			RAILWAYS AND TRAMAYS.								
£2,850	10	7½	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
50,000	£10	..	City and South London Railway	3	5	3	5	..	..	..	..

* 7 per cent. for half-year ending 30th June, 1891 (making 7 per cent. for year); 3 per cent. in completion of payment of arrears of Cumulative Preference dividend for year ending 30th June, 1885; 7 per cent. in payment of arrears of Cumulative Preference dividend for year ending June, 1888.

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NOTES.

One of the most useful and certainly most disinterested efforts of the London County Council has been their action in demanding a better standard of light than the "Parliamentary candle." One of the highest authorities on this subject, as well as on the complicated art of gas testing, which is generally called photometry, is Mr. W. J. Dibdin, the chemist to the Council. The credit of this movement is probably due to him; and although the matter seems to be essentially one which should have been taken up by the Standards Department of the Board of Trade, the joint action of this body with the London County Council, financed in a truly British fashion by the public spirit of the South Metropolitan Gas Company, will no doubt lead to a practical issue. The effort is to obtain a more exact standard, not necessarily a new one. The candle is a unit of very convenient magnitude, and it is to be hoped that the construction of the new standard will be confined to reproducing the mean value of the old candle.

A very just complaint was made by a correspondent to the *Financial News* on the 7th inst., that he had been canvassed by a firm of contractors who solicited the wiring of his house, they representing themselves to be the engineers of the local supply company. Their tender was accepted on the assurance that current would be supplied at once; but with the ingenious and thoughtful stipulation that the cost of wiring would not be paid for until the current was supplied. Like many others, the owner of the house has been daily reminded of the blessings of electric light by empty lamp-holders, if not dangling wires; and for a twelvemonth, while the newly decorated house has been soiled by gas, he has waited for electric current, and the contractors, probably with equal impatience, have waited for current coin. On applying to the supply company he learns that they will put down the necessary mains for £350, and they generously offer to expend this sum for this purpose if he will take 35 shares at £10 each. The Company, having repudiated the authority of the contractors to make promises as to the date when the current would be supplied, is giving the matter further consideration. Such promises, or at all events assurances, are not uncommon, and the precaution adopted in this case will probably deter imaginative contractors from making rash guarantees.

In giving his judgment in an action brought by an Edinburgh electrotyper against a Newcastle firm of dynamo maker, Lord Kyllachy, as will be seen in our Legal Intelligence columns, arrived by a process of elimination face to face with a somewhat unpleasant alternative. The dynamo in dispute was supplied in September last year, proved unsatisfactory, and was ultimately returned. The plaintiff said the machine was at fault; the defendants blamed the bath and the general arrangements, and disclaimed all idea of having contracted to furnish a dynamo for the particular purpose of electrotyping. According to Lord Kyllachy, neither side proved its case in Court. The dynamo had, however, been fetched back from Newcastle, where it had lain several months, and had been tested with highly satisfactory results. This fact, said the Judge, left him no alternative but to "assoilzie" the defendants or to infer fraud on their part; and there being no evidence whatever in support of such a charge, he naturally preferred to sit on the more comfortable horn of the dilemma which he had conjured up.

An important addition to our knowledge of phosphorence has been recently made by M. Henri Becquerel, and a brief account of his experiments will be found in the *Comptes Rendus* for November. The elder Becquerel, the inventor of the phosphoroscope, found that the light given off by a phosphorescent body diminished according to an exponential law of the time. The law, however, was merely approximate, and was only supposed to apply for short intervals of time. By studying the behaviour of bodies which remain shining for several minutes after the removal of the incident light, M. H. Becquerel has succeeded in finding a law which represents, with considerable accuracy, the manner in which the light fades away. In order to account theoretically for his results, he supposes that the molecular vibrations, to which the phosphorescence is due, are resisted by the medium in which they occur in much the same way as the oscillations of a galvanometer needle are gradually decreased owing to the resistance of the surrounding air. He assumes that the resisting force is proportional to the square of the velocity, and finds that the intensity of the phosphorescent light is represented by the reciprocal of $(a + b\,t^2)$, where a and b are constants, and t is the time reckoned from the removal of the incident light. This law is apparently closely fulfilled if the phosphorescent substance only gives out one kind of light. When a mixture of lights is emitted by the substance, the law in its simple form no longer holds, for it is found that the

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values of a and b vary with the colour of the light. Thus when a substance emits two kinds of light, the expression for the intensity of the glow consists of two terms, each of the same form, but with different values for the constants a and b. These facts have been verified by experiments on calcium and other salts, the luminosity of which persists for more than half an hour after the removal of the light. The agreement of the experimental measurement with the numbers deduced from the formula is very close; yet, as there are as many as four constants at disposal, the results are not more concordant than one would be led to expect. M. BECQUEREL'S theory would have been more thoroughly proved if the light had been examined through coloured glasses, so as to separately investigate the light corresponding with the different terms in the formula.

AFTER giving a brief sketch of the very meagre state of knowledge of the heating of conductors by electric currents, we observed last week that nothing of importance had been done since 1889 until the recent reading of a Paper before the Royal Society on the subject; and whatever criticisms may have been offered, there can be no question that the Paper was, as we remarked, of importance. Criticism of scientific work differs widely from that of the drama, art, or literature, because, whether made at a discussion after the reading of a Paper, or in the columns of a technical paper, every facility is open to the author for explanation or, if need be, of refutation. The abstract of this Paper was not full enough to justify further criticism, and our comments were chiefly aimed at elucidating various points which were not sufficiently described. Such elucidation can come only from the authors; but only a few additional details have reached us, and these have come by a very roundabout channel. The dimensions of the water-jacket cylinder were, we hear, 32·5 centimetres long, by 7·62 centimetres external, and 5·8 centimetres internal diameter; it was of course placed horizontally. The experiments were made with the view of ascertaining the behaviour of wires in Cardew voltmeters. The curves which we had constructed were not the same as those accompanying the Paper, and the peculiar disturbances we observed in them were due, it is suggested, to irregularities in the composition of the wires or errors in measuring their diameter. The investigation of the heating of very thin wires is of course new; our sketch showed that little was known about it except that the ordinary law was not followed; and it is possible that the complete Paper, which we understand represents a very large amount of work, may contain information of a more generally applicable character than the abstract foreshadowed.

Nottingham.—The Town Council has empowered a special committee to spend £25,000 to £30,000 in lighting a central section of the borough by electricity.

St. Ives (Hunts).—At the last meeting of the Town Council the desirability of adopting the electric light was referred to a special committee for investigation and report.

Plymouth.—The Board of Trade give notice that they have revoked the Plymouth Electric Lighting Order, 1890, and that the revocation is to take effect from November 24th.

Royal Society.—The following Paper was down for reading yesterday before the Royal Society:—"Repulsion and Rotation produced by Alternating Electric Currents," by G. T. Walker.

Zonal Spherical Harmonics.—The December number of the *Philosophical Magazine* contains Prof. J. Perry's Table of Zonal Spherical Harmonics, together with several worked-out examples.

Lambeth Vestry.—The House-to-House Electric Company offered to transfer its Order to the Vestry at a price equivalent to the estimated cost of obtaining a new Order by the Vestry. The offer has been declined.

Richmond (Surrey).—At a meeting of the Town Council held on Tuesday, it was decided by a large majority to seal a contract with Messrs. Latimer Clark, Muirhead and Co., for the electric lighting of Richmond, for a period of 30 years.

Glasgow.—At the meeting of the Town Council last week it was decided, by 56 votes to 7, to go on with the low-pressure scheme of electrical distribution, and to employ the services of Prof. A. B. W. Kennedy as consulting engineer.

Telephone Licences.—The Secretary to the Post Office has intimated to Mr. A. Erskine Muirhead, Managing Director of the Caledonian Telephone Company, that the Government will now receive their application for a licence for exchange business.

Telephony in Greece.—A telephonic service will be established next spring between Athens and the Piræus, and the necessary apparatus has already been ordered. The yearly subscription will be 200f. in Athens and 175f. in the Piræus.

Bilbao.—*Industries* reports that a successful trial has been made with an electric tramway at Bilbao. The work of transformation from a horse line to an electric line has been going on for more than two years. The current will be supplied by overhead conductors.

Old Students' Association.—A most successful smoking concert was held on Friday last at Masons' Hall Tavern. A very first-rate programme was provided, and there was a large attendance of members and friends. The hon. secretary announced the names of no less than 27 new members and associates.

Overhead Telephone Wires in Sheffield.—The Chief Constable reports that an accident has occurred to a fire escape on account of insufficient headway between certain overhead telephone wires and the surface of the street; and the borough surveyor has been instructed to write to the two telephone companies, requesting them to have all overhead wires crossing public streets altered so as to leave a clear headway of 35 feet.

Electricity in the City.—At the meeting of the Common Council last week it was stated that the present electric light standards were not approved of, and were going to be removed. It was also stated that the electric lighting of the Mansion House was progressing satisfactorily, and the light would be tested this week. If the lighting of the City streets was postponed it would not affect the Mansion House, because it would be lighted by a special wire.

A Damaged Cable.—The cable off Lowestoft, known as the Northernmost Cable, the property of Reuter's Agency, has been severed, presumably by a vessel dragging at her anchor during the fog on Monday night. The cable, which communicated with Germany, was laid in 1866, and it has been ascertained that the damage sustained is about ten miles east from the Corton Light. The work of repairing the cable will be at once proceeded with by the s.s. "Monarch."

Electric Launches for the Seaside.—Mr. W. S. Sargeant, of Chiswick, has been successful in gaining the £25 prize as offered by the Paignton Promenade Pier and Torquay Ferry Company, for the best designs and drawing for electric launches plying between Paignton and Torquay; also for a 65ft. steam launch to carry 100 passengers for the proposed trip round Torbay. The vessels are to be built in the best possible manner and to the Board of Trade's requirements, and to be delivered at Torquay on May 1, 1892.

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Hull.—At the last meeting of the Electric Lighting Committee of the Council the minutes of the Sub-Committee, containing the electrical engineer's recommendations and report, were confirmed. The plant required is to be capable of supplying 8,500 8 c.p. lights in the first instance. Siemens' shunt-wound dynamos, running at 115 and 150 volts (the latter for charging accumulators if necessary), are recommended, the former being 115 unit, and the latter 45 unit machines. A modification of the Crompton system of mains is proposed.

The Theatrophone in London.—A preliminary trial of several theatrophones was made at the Savoy Hotel on Tuesday evening last. The machines used are similar to the latest which have been introduced into many Paris clubs and restaurants, and are worked on the "coin-in-the-slot" principle. Connection was only established with one theatre—the Savoy. Under these favourable conditions the music of the opera was heard with all purity and clearness, and with good volume of sound. The idea is to supply London with theatrophones in the same way as telephones are now provided.

Cable and Land Line Interruptions and Repairs:

	Date of interruption. 1891.		Date of repair. 1891.
St. Thomas-St. Kitts Cable	Oct. 13	... .	*
Cayenne-Vizeu Cable	„ 22	.....	*
Saigon Bangkok Line	„ 31	.....	Nov. 7
Transandine Line	Nov. 1	.....	„ 1
„ „	„ 3	.....	„ 4
„ „	„ 14	.....	„ 16
Moulmein-Bangkok Line	„ 12	.....	„ 18
Brest-St. Pierre Cable (Anglo-American)	„ 19	.. ..	*

* Not yet repaired.

Royal Institution.—The following are some of the lecture arrangements before Easter:—Dr. J. A. Fleming, three lectures on the Induction Coil and Transformer; the Right Hon. Lord Rayleigh, six lectures on Matter—at Rest and in Motion. The Friday evening meetings will begin on January 22nd, when a discourse will be given by the Right Hon. Lord Rayleigh on the Composition of Water; succeeding discourses will probably be given by Prof. Roberts-Austen, Sir David Salomons, Dr. Oliver Lodge, Prof. W. E. Ayrton, and others.—At the last general monthly meeting of the Institution the special thanks of the members were returned for donations from Prof. Dewar, for structural alterations; from Mr. Ludwig Mond, for new pressure pump.

Cable Interruptions and Repairs.—The Eastern Extension Company notifies the interruption of the Hong Kong-Manila cable. Until its restoration telegrams will be sent by post by every available opportunity. A mail boat leaves Amoy for Manila to-day (Friday). Telegrams will be posted by this mail, and if the cable communication should be restored before its arrival at Manila, they will also be transmitted by wire to their destination. The cable, together with three others in the neighbourhood, was broken by a typhoon, and the bad weather which still prevails may retard the repairing operations.—The Eastern Telegraph Company notified early in the week that communication with Zanzibar and South Africa was interrupted by both the East and the West Coast routes, but, on going to press, we learn that telegraphic communication with South Africa has been restored by the latter route.

The Standard of Light.—The Board of Trade has undertaken to appoint a committee to consider what the standard of light for testing the gas supply of London should be. The appointment of the committee has been delayed because the Board of Trade and the London County Council had no fund available for paying the expense of a committee. The South Metropolitan Gas Company have now undertaken to pay the whole of the expenses, and the committee will very shortly be formed. It will consist of two members nominated by the County Council, one by the City Corporation, three by the London gas companies, together with the three gas referees and two independent scientific men. Dr. Frankland and Mr. Dibdin, the Council's chemist, will represent the London County Council. Pending the report of this committee, the Council has deferred action in the direction of obtaining legislation for a more exact standard of light.

Obituary.—We regret to record the death of Sir Arthur Blyth, Agent-General in London for South Australia, on Monday. He was born in Birmingham in March, 1823, and was educated at King Edward's Grammar School in that town. He left England for Australia in 1839, and was engaged in business until 1861. He was subsequently elected a member of the South Australian Parliament under the new Constitution. He took a leading part in many Ministries, being three times Premier of South Australia. He was appointed Agent-General in February, 1877, on the death of Mr. Francis Dutton, C.M.G. After this appointment he received the honour of Knighthood from Her Majesty, and was created Knight Commander of the Order of St. Michael and St. George, and Companion of the Bath. Sir Arthur Blyth took an active and leading part in the negotiations which led to the rates for telegrams between this country and Australia being largely reduced, under the joint guarantee of some of the Australian colonies and the telegraph companies concerned.

An Important Water Power Scheme.—The Société des Eaux de la Dranse have at their disposal a waterfall formed by a derivation from the river Dranse, which flows into the Rhone near Martigny (Valais). The head available amounts to some 660ft., the flow being nearly 180 cubic feet per second, the power disposable at the turbine shaft being therefore about 10,000 H.P., allowing 25 per cent. loss in the turbines and pipes. The cost of canals, dams, pipes, reservoirs, &c., is estimated at £56,000. Close by there is a large expanse of level ground admirably adapted for factories, &c., and a railway line running to Lausanne. The Société invites schemes for the utilisation of 6,000 H.P. for various purposes, and more especially in connection with the reduction of aluminium, the manufacture of chlorate of potash, and electro-metallurgical works. The Société offers a first prize of £160, a second of £80, and a third of £40. The schemes must be received by midday on February 29, 1892, by MM. Cuénod-Churchill et Fils, bankers, Vevey (Vaud), Switzerland.

The Roundhay Electric Tramway and the Telephones.—At a meeting of the Tramways Section of the Highways Committee of the Leeds Corporation on Monday, a deputation from the National Telephone Company complained that the telephonic system on the Roundhay Road section was being seriously interfered with by the electric tramway current. Dr. John Hopkinson and Mr. Winterbotham, who represented the interests of the Telephone Company, pointed out that the electric current made a buzzing noise in the telephone, and that operators could distinguish when a car was on the line and when it was ascending an incline. Between 20 and 30 users of the telephone living between Sheepscar and Roundhay allege that they cannot hear anything that is said to them. Mr. Graff Baker and Mr. Winslow, who attended on behalf of the lessees of the electric tramway, replied that their wires were run and their cars worked exactly as in America. The Committee having heard all that both parties had to say, decided to leave the two companies to settle the matter between them.

Economy of an Electric Mining Plant.—In a Paper recently read before the Engineers' Society of Western Pennsylvania, Mr. C. F. Scott drew a comparison between hand labour and machine labour for coal-mining. In machine mining the stalls can be made much wider because of the greater rapidity of mining, so that the roof will stand a shorter time with fewer pillars. The immediate effect of the introduction of coal-cutting machinery is to reduce the cost of undercutting from 20d. to 5d. per ton of 1¼in. coal in the Pennsylvania district. Taking into account the other expenses, there is a saving of 25 per cent. Another advantage of machine mining is that perfect pillars are left, and can be recovered, as there is no temptation to rob them. The reduction of the number of stalls for the same output, due to machinery, also causes a great saving in the timber, the number of roads, and the tramways that have to be kept up. The saving in coal, due to the introduction of machinery, is also very great; this arises from the small amount of slack and the larger coal produced by the smaller height and greater depth of undercutting, and also from the pillars not being crushed. An estimate is given of the saving in expense

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by using a plant of seven machines, run ten hours a day, and cutting 233 tons. The cost is £29. 11s. 3d., made up as follows:—Fuel, 9s. 7d.; wages, £2. 10s.; deterioration of boiler, engine, electrical apparatus, and wire, £1. 6s.; cost of repairs, £1. 0s. 8d.; cost of working, £4. 17s.; loading and blasting, £19. 8s. The indirect saving is estimated at £2. 19s. The cost of hand mining is £38. 6s. 8d. The saving by the use of machines is therefore considerable in all directions.

Chicago Exhibition.—The report of Director-General Davis upon the subject of awards and juries has been submitted to a sub-committee. The Director-General says that if the jury of awards is organised by July 1, 1893, its work can be completed substantially by August 16th, and the work of revision finished by September 1st. The number of jurors required he estimates, after consultation with the chiefs of thirteen departments of the Exposition in which exhibits will be entered, is 659. Machinery—Six juries, thirty-six judges. Electricity—Five juries, thirty-five judges. Colonel Davis also recommends that a special jury be drawn from the regular group of juries, to give an award to the exhibit showing the best and most satisfactory installation in each of the thirteen departments. Each of the judges is to be paid six dollars a day for his services, which are not to exceed forty days. Colonel Davis believes that 130,000 dollars will be enough to pay the judges. He recommends further that the policy of the Exhibition should be very conservative in respect to the number of awards, and that the authorities should study how they will be able to limit rather than to enlarge the number.——At a recent meeting of the Committee on Electricity, Electrical and Pneumatic Appliances, the following names were decided upon as those of eminent electricians not now living, to be placed over the Electricity Building at the Exposition:—Franklin, Galvani, Ampère, Faraday, Ohm, Sturgeon, Morse, Siemens, Davy, Volta, Henry, Oersted, Coulomb, Ronald, Page, Weber, Gilbert, Davenport, Soemmering, Don Silva, Arago, Daniell, Jacobi, Wheatstone, Gauss, Vail, Bain, De la Rive, Joule, Saussure, Cooke, Varley, Steinheil, Guericke, La Place, Channing, Priestley, Maxwell, Coxe, Thales, Cavendish.

The Hum of Motors.—The hum given out by motors when working under heavy loads being a matter of interest, as having a practical bearing upon the subject of "motor design," I undertook, says Mr. S. W. Huff, in the *Electrical Engineer* of New York, some experiments with a view to learning the cause of it. The motor selected for the experiment was an eight-pole machine, wrought-iron field-cores and pole-pieces, with a Gramme ring-toothed armature. When the fields were unexcited and the armature was revolved at any reasonable speed, there was no sound given out, but as soon as a strong current was sent through the fields a musical hum was heard, the note increasing in force with the increase in current through the fields, and increasing in height of pitch with the increase in speed of the armature. Not having convenient anything of known pitch, the number of revolutions was carefully noted just when the note given out was beginning to be audible, *i.e.*, when the vibrations producing this note would be about 16 per second. From a number of observations it was found that when the note given out was barely audible the speed of the armature was about two revolutions per second. Since the motor had eight poles, at the time of observation any point in the armature was passing from one pole to the next 16 times per second; and since the number of vibrations per second causing the hum corresponds exactly with the number per second of changes in polarisation of the armature, it is but natural to conclude that the change in polarisation of the armature as it passes from one field pole to the next is the cause of the musical note given out by motors. The annoyance has been often lessened by reshaping of pole-pieces. The fact that the force of the musical note increased with increase in the current through the fields would seem to show that the note increased in force with increase in saturation in the magnetic circuit taken as a whole, and that a reduction in the possible saturation through the magnetic circuit as a whole would decrease the force of the note.

The Berliner Microphone Patent.—"Rarely," says the *Electrical World*, "has a patent on any subject whatever caused so profound a sensation as the granting to Emile Berliner on November 17th of what on its face appeared to be a broad claim on the microphone transmitter now used well nigh universally wherever the telephone exists. Electrical circles were less surprised than the general public, but a feeling akin to consternation has pervaded the atmosphere during the past week. It is, indeed, an extraordinary patent, no less on account of the sweeping character of some of its claims than by reason of its remarkable history in the Patent Office. There are various lines of attack on the transmitter patent that will doubtless be assiduously followed so soon as the subject comes before the Courts. The fact is that albeit the Berliner microphone patent is broad and of unquestionable importance, it has by no means so great a value to the telephone monopoly as would make it vitally necessary that it should be sustained. A large number of subsidiary and accessory patents on telephonic apparatus of an infinite variety, as well as the commercial security assured by immense plants and important franchises, are likely to give the present telephone organisation a lease of life extending considerably beyond the expiration of the famous 1876 patent, quite independent of the transmitter now in question." In the same issue (November 28th) our New York contemporary devotes several columns to an interesting discussion of the various questions connected with the granting of the Berliner patent, and the possibility of its being upset or avoided. Elisha Gray's device for producing variations of electrical resistance by means of a vibrating diaphragm connected to electrodes placed in a minute liquid rheostat, is considered, by the *Electrical World*, as a possible anticipation of Berliner's broad claim to the production of electrical undulations by causing sound waves to vary the resistance of an electric circuit, comprising electrodes in constant contact. If it is a question of "getting round" the Berliner patent, we would suggest a trial of Chichester Bell's water-jet transmitter (see *The Electrician*, Vol. XXI., p. 375).

The Electrical Trades Section.—Speaking on Wednesday at the quarterly general meeting of the London Chamber of Commerce, Mr. Crompton (Chairman of the Electrical Trade Section) stated that his was one of the youngest sections of the Chamber. A very mistaken idea regarding the nature of electricity was abroad only a short while ago, and it was thought that it could not be dealt with on commercial principles. The public had had to be educated in all these matters. They had had to memorialise the Government to provide them with accurate standards of measurement which could be compared in Government departments in the same way as other standards; and by the action of the Chamber they had succeeded. Another important matter upon which they had used their offices to remove misconception on the part of the public had been in connection with overhead wires. Nearly everyone grumbled about the metropolis being disfigured by a network of overhead wires. There were two sides to this question, and few were aware that it was mainly the want of regulation as to overhead wires that was to blame for that about which so much complaint was heard. If those who put up these wires were possessed of Parliamentary powers they would be able to cross the streets in a compact block at intervals, and the cause of complaint would be almost entirely removed. This plan had been carried out in many Continental towns, and scarcely any disfigurement of the streets was perceptible. Their section of the Chamber had been of considerable use to the profession in connection with visits to Continental Exhibitions. Exhibitions had been a very great tax on the trade in the past few years; but, he thought, now that those conducting these Exhibitions knew that the trade had a centre in the London Chamber of Commerce, that the interests of exhibitors would be better consulted than they had been in the past. They had a long list of useful works before them. He might mention, among other things, that their trade was now proposing to begin a system of beds in convalescent homes for their *employés* who had been incapacitated from work; and he thought that this system might be usefully followed by other trades. As, however, they were themselves young and energetic, they would, perhaps, have the credit of taking the lead in this matter.

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THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 118.*)

§ 35. **Action of One Current upon Another** (*see* § 21).—We have seen (§§ 20, 30) that the mutual potential energy of a current of strength i, flowing in any circuit A, and any magnetic system, is equal to $-Ni$, where N is the number of lines of induction due to the magnetic system which would pass through A if the the current were not flowing, the positive direction for the lines being that of the lines of induction due to the current itself. We have now to consider the case in which the magnetic system is another electric current of strength i'. Suppose that when no current flows in A and unit current flows in the second circuit B, M lines of induction pass through A. Then, if a current i' flows in B, the number of lines through A will be Mi', since the magnetic force everywhere is proportional to the strength of the current. If now a current i flows in A, in such a direction that its own lines of induction pass through it in the same direction as those due to B, the mutual potential energy of the two currents will be $-Mii'$. The quantity M is called the Coefficient of Mutual Induction of the Two Circuits. This expression $-Mii'$ really contains the whole theory of the mutual action of two currents, and from it all the actions between them can be deduced.

We see from the form of the expression for the mutual potential energy of the two currents, that the number of lines of induction which pass through the circuit A (when it carries no current), due to unit current in B, is equal to the number which pass through the circuit B (when it carries no current) due to unit current in A. Considering that the two circuits may be of any shape or size whatever, we must regard this result as a remarkable reciprocal theorem.

§ 36. **Number of Lines of Induction through a Circuit.**—This number N can be calculated by two different methods. The first consists in simply counting how many lines of induction pass through the circuit, the second in finding how many lines have *cut through* the circuit while it is brought up from an infinite distance to its actual position. Since a line of induction is closed upon itself, the only way in which a line can link itself with the circuit is by cutting through it. It is clear then, that by taking a proper account of the number of lines which have cut through the circuit during its journey from infinity, we shall be able to determine the number which pass through the circuit, and are, therefore, linked with it in its actual position.

§ 37. **First Method of Finding N.**—Close up the circuit by any surface S, and calculate the magnetic induction at all points of this surface. Let $\mathbf{B}$ be the magnetic induction, and θ the angle it makes with the normal to the surface at any point. The normals must always be drawn from the *same* side of the surface. Let α be any small area on the surface; the number of lines of induction passing through α is $\mathbf{B}\cos\theta\,.\,\alpha$. Taking the sum of all these quantities for the whole of the surface bounded by the circuit, we find $N = \Sigma\,\mathbf{B}\cos\theta\times\alpha$. In the notation of the integral calculus we write this $N = \iint \mathbf{B}\cos\theta\,dS$, the double integral being put to remind us that the integration is taken over a *surface*. In making this calculation we may make S of any shape we please, the only limitation being that it must have the given circuit for its boundary. Thus, if the circuit is a circle we may make S a plane or a part of a sphere, according as is most convenient for our analysis.

§ 38. **Second Method of Finding N.**—According to the principle laid down in § 36 we can find N by determining how many lines of induction cut across each part of the circuit while it is brought up from an infinite distance to its actual position, and adding all these numbers together for the complete circuit, the contribution from each part being taken with the proper sign. From any point, P, in the field draw a short straight line, P Q, in any direction. If P Q is brought up from an infinite distance to its present position, P Q always retaining a fixed direction, a definite number of lines of induction will have cut across P Q. Since the linking of a line of induction with the circuit is the opposite of the unlinking, we must have some criterion to enable us to decide when the passage of a line of induction across P Q is to be considered positive, and when negative. We shall adopt the following specification. Let an observer stand with his feet at P so that the lines of induction run in the direction of feet to head. Let him look along in the direction in which P Q is drawn. If as P Q moves along carrying the observer with it, a line of induction passes in front of the observer from right to left, its passage across P Q is to be counted positive; but if it passes from left to right, then the passage is to be counted negative. Now, the number of lines of induction which have cut across P Q per centimetre of its length depends upon the direction in which P Q is drawn, and for one direction is the greatest possible. This maximum number is called the "vector potential" at P, and is denoted by $\mathbf{A}$, while the corresponding direction is called

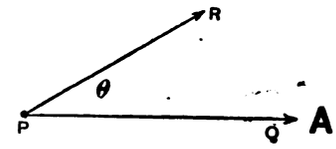

Fig. 37.

the direction of the "vector potential." Since when both the direction and magnitude of the "vector potential" are known, this quantity is completely defined, it follows that it is a vector; we may therefore apply the rules of vector analysis to it. Thus it follows at once that if we draw any very short line, P R (Fig. 37), making an angle θ with P Q the direction of the vector potential, then the number of lines of induction which have crossed P R per centimetre of its length in the positive direction, while P R has been brought up from an infinite distance to its present position is $\mathbf{A}\cos\theta$, or is the resolved part of the vector potential in the direction P R. P R is, of course, always to be kept in a fixed direction during the motion. It is also clear that if P Q is the direction of the vector potential at P, then if P R is drawn at right angles to P Q, no lines of induction will on the whole have crossed P R.

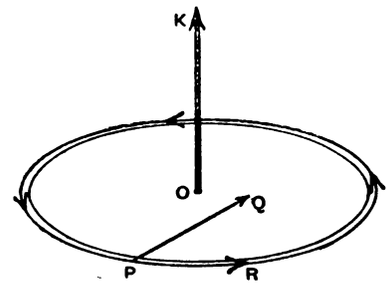

Fig. 38.

We can now write down the number of lines of induction which pass through any circuit in terms of $\mathbf{A}$. Let $\mathbf{A}$ be the value of the vector potential at any point P of the circuit (Fig. 38), θ the angle between its direction P Q, and that of the element P R ($=\sigma$) of the circuit. If we wish to find the number of lines of induction through the circuit in the direction indicated by the arrow O K we must always draw σ in the direction of the arrow P R, the two directions being related to one another in the same way as the translation and rotation of a right-handed screw. This is only another way of expressing the specification laid down above. The number of lines of induction which have cut across σ in the positive direction, while the circuit has been brought up from an infinite distance is $\mathbf{A}\cos\theta\,.\,\sigma$. Taking the sum all round the circuit we have for the total number of lines of force which pass through the circuit, or are linked with it, $N = \Sigma\,\mathbf{A}\cos\theta\cdot\sigma$. Employing the notation of the integral calculus $N = \int \mathbf{A}\cos\theta\,ds$, ds being an element of the circuit, and the integration extending all round

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the circuit. We have now shown how to find N by the second method.

§ 39. Thus N can be expressed either as a surface integral $N = \iint \mathbf{B} \cos\theta\, dS$, or as a line integral $N = \int \mathbf{A} \cos\theta\, ds$. The idea involved in the expression of a surface integral in terms of a line integral was originally due to Prof. Sir G. G. Stokes,* and has led to very many improvements in the theories of hydrodynamics, electromagnetism, and other subjects involving the same type of analytical methods. The definition of the vector potential given above is really the same as that given by Maxwell; the present mode of expressing it is that given by Dr. Fleming in "The Alternate Current Transformer" (p. 352), and, as we shall see presently, leads to an easy method of obtaining Neumann's formula.

§ 40. **Vector Potential of an Element.**—We shall now show how the value of A at any point due to a current flowing in any circuit may be expressed in terms of the geometrical configuration of the circuit. Take an element of current of length σ and strength i (Fig. 39). Let O be the centre of σ. Let P be the point at which the vector potential is to be found, and let $OP = r$. Draw P Z perpendicular to the continuation of σ, and let P′ be any point on Z P, and let the angle $P'OZ = \theta$. Draw a short straight line P′ Q′ parallel to σ. Now, by § 32 we have seen that the magnetic force at P′ due to the element $i\sigma$ is $i\sigma \sin\theta / OP'^2$ at right angles to the plane O Z P′. Since we are only dealing with air this is also the value of the magnetic induction. When P′ moves through a small distance, x, towards Z, it is cut through in the positive direction by $i\sigma \sin\theta\, x / OP'^2$ lines of induction per centimetre of its length. But if a

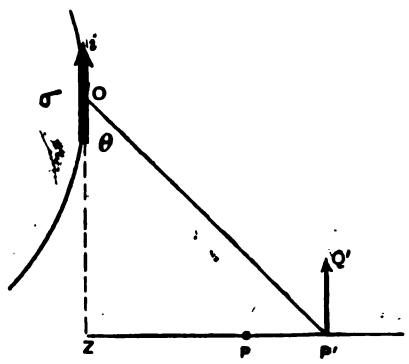

Fig. 39.

pole of strength $i\sigma$ were placed at O, the magnetic force at P′ would be $i\sigma / OP'^2$ along O P′, and the resolved part of this in the direction Z P′ would be $i\sigma \sin\theta / OP'^2$. The work spent upon a unit pole in moving it along P′ Z through a small distance, x, towards Z, is, therefore, $\frac{i\sigma \sin\theta}{OP'^2} x$, the same expression as we found for the number of lines of induction which cut across P′ Q′ per centimetre while it is moved through the distance x.

Thus we see that the whole number of lines of induction which have cut across the moving line per centimetre of its length while it is brought up from an infinite distance is equal to the work spent upon bringing up a unit pole to the same place in presence of a pole of strength $i\sigma$ placed at O. In other words, the value of the vector potential at any point, P, due to the current element $i\sigma$ at O is equal to the magnetic potential at P due to a pole of strength $i\sigma$ at O. The magnetic potential is $i\sigma / r$ (*see* § 17), and accordingly $i\sigma / r$ is the value of the vector potential at P due to the element of current at O. The *direction* of the vector potential is clearly that parallel to the element of the current, for if we had drawn P′ Q′ in any other direction, and had kept it parallel to that direction during its motion from infinity, lines of induction would have cut across any straight line drawn at right angles to P′ Q′, and P′ Q′ would not be the direction of the vector potential (*see* § 38). The form of the expression (*see* § 17) for **A** explains the second half of **A**'s name.

* Smith's Prize Examination, 1854.

§ 41. **Neumann's Formula.**—If we wish to determine the value of **A** at any point due to a current in any closed circuit, we can do this by finding the value of the vector potential due to each element of the circuit, and then adding all these quantities together by the process of vector addition. The resultant is the value of **A** at the point. It is the same as the resultant of a set of forces, each of which is the vector potential due to an element of the current. Although on account of the indeterminate nature of the action of an "element" of a current, the vector potential due to it is indeterminate; yet if we make use of the formula of § 40 in calculating the vector potential of a complete circuit, the result will be perfectly definite.

For it was shown in § 32 that the magnetic force at any point due to a closed circuit is the same as the resultant of a system of magnetic forces $i\,ds \sin\theta / r^2$ at right angles to the plane of r and ds. Each of these magnetic forces may be resolved into two components normal and parallel to the plane containing the moving line and the direction of its motion. Each component may be represented by an appropriate set of lines of induction in its own direction (*see* § 12). It is clear that only the component normal to the plane is cut across by the moving line. But the sum of the parts of any system of vectors resolved in any direction is equal to the resolved part of their resultant in that direction. Hence the actual number of lines of induction intersected by the moving line during any small displacement (this number is quite definite since it depends on the *resultant* magnetic force) is the same as the number which would have been intersected if each element of the current had produced a magnetic force $i\,ds \sin\theta / r^2$. But the

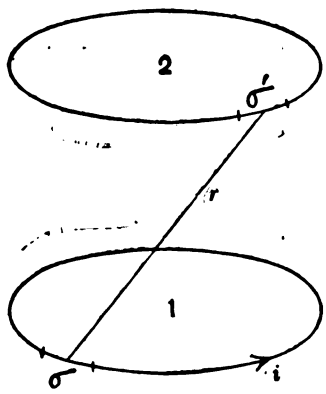

Fig. 40.

number of lines of induction belonging to any element which have been cut through by the moving line is the resolved part of the vector potential in the direction of the line. Hence the vector potential of any *closed* circuit is the same as if *each* element produced a vector potential $i\,ds/r$ parallel to ds. We may, therefore, calculate the vector potential of a closed circuit by this formula without any error or uncertainty.

We shall now find the value of N (§ 36) for the circuit (2) (Fig. 40) due to a current, i, flowing in (1). Let σ, σ' be two elements of (1) and (2), r being the distance between them Let ϵ be the angle between the directions of σ and σ'. The vector potential at σ', due to $i\,\sigma$, is $i\,\sigma/r$. Hence, the number of lines of induction which cut across σ', while (2) is brought up from an infinite distance, is $\sigma' . i\sigma \cos\epsilon . 1/r$. Thus the whole number which have cut across σ', due to the complete circuit (1), is $i\sigma' \Sigma\sigma \cos\epsilon . 1/r$, the summation taking in every element of (1). This expression is free from any indeterminateness. From this we find at once that the whole number of lines through (2), due to current i in (1), is $N = i \Sigma\sigma' \Sigma\sigma \cos\epsilon . 1/r$, the new summation taking in every element of (2). We may write this $N = i \iint ds\, ds' \cos\epsilon . 1/r$, ds, ds' being elements of (1) and (2), and the integration extending round both circuits. But $N = M\,i$, so that $M = \iint ds\, ds' \cos\epsilon . 1/r$. This remarkable formula is due to F. E. Neumann. We have seen that it expresses the whole number of lines of induction through (2) due to unit current in (1). The quantity $ds\, ds' \cos\epsilon . 1/r$, which occurs under the sign of integration, may be regarded as the

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number of lines of induction due to *ds*, which have been cut across by *ds'* in its journey from infinity.

§ 42. The quantity M is called the coefficient of mutual induction of the two circuits. From the symmetry of M with regard to the two circuits we see that the number of lines of induction through (1) due to unit current in (2) is equal to the number of lines through (2) due to unit current in (1). This result also follows at once from § 35. M is clearly a quantity of the dimensions of a *line*, so that if the measurements of the two circuits are made in centimetres, the value of M will also be expressed in centimetres. When we are dealing with large coils of wire of many turns, M becomes very large when expressed in terms of centimetres, and on this account among others a larger unit is sometimes used. This unit is 10^9 centimetres, approximately the length of a quadrant of the meridian of Paris. It was thus convenient to speak of 10^9 centimetres as a quadrant. Again, since on the electro-magnetic system the ohm is 10^9 centimetres per second, the name Secohm was given to 10^9 centimetres since that is the distance described in a second by a body moving with a velocity represented by one ohm. But lately, in response to the request of the American electricians, a new name has been introduced for this quantity, viz., "the henry," as a tribute to the investigations of Prof. Joseph Henry, in the science of electro-magnetism. We shall, however, always retain the C.-G.-S. unit pure and simple.

(To be continued.)

THE FÉRY AUTOMATIC SWITCH.

The necessity of automatic switches in charging circuits, says our Paris correspondent, was felt at a very early date; and the first apparatus of this description was that of M. Hospitalier, described in *La Lumière Electrique* of June 15, 1880. This switch, however, required regulating every time the number of accumulators to be charged was altered, and it was modified later on so as to avoid this (*L'Electricien*, June 26, 1886).

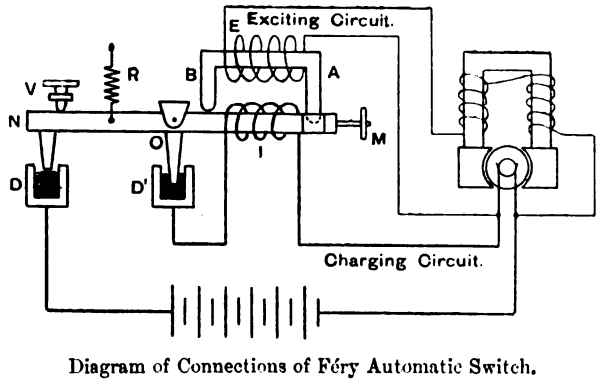

Diagram of Connections of Féry Automatic Switch.

The switch brought out by M. Ch. Féry is, for reasons of construction, of the regulating type. It consists of an iron lever N O M (see diagram), which carries two rods which plunge into the mercury cups D D' and close the charging circuit. The iron core A B is surrounded by the coil E, which is interposed in the shunt circuit of the dynamo, and the coil I is traversed by the main charging current. A spring R and a weight M, movable along a screw thread, allow the apparatus to be regulated.

When the electromotive force of the dynamo has attained its proper value, the electro-magnet A B attracts the lever N O M, which revolves around the axis O, and closes the charging circuit; the current which then traverses I helping to keep the circuit unbroken. When the speed of the dynamo is continuously reduced, the current in each coil will also diminish, and the pull of the spring R will soon preponderate, and the circuit will be broken. When the instrument is properly regulated the circuit is broken at the very moment when the current is zero.

In practice the number of cells in a battery of accumulators is often altered, and then the spring R and the weight M have to be manipulated. If by any chance this manipulation is forgotten, and the circuit is made when the volts at the dynamo terminals are less than those at the terminals of the battery, the reverse current will polarise the lever, and the circuit will be broken. The lever will then continue to oscillate like an electric bell hammer, and the attendant will be warned by the noise of the mistake. This apparatus is, therefore, a guarantee against accidents; and the strong practical shape given to it by the maker, M. Ducretet, makes it commercially useful.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, December 11th. (To-day.)

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read:—"Meters for Recording the Consumption of Electrical Energy." By C. H. Wordingham, A.K.C., Stud. Inst. C.E.

TUESDAY, December 15th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed:—"The Sale of Water by Meter in Berlin." By Henry Gill, M. Inst. C.E.

WEDNESDAY, December 16th.

INSTITUTION OF CIVIL ENGINEERS.

2 p.m. Students' visit to the stations of the Westminster Electric Supply Corporation.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary meeting. Papers to be read:—(1) "Report on the Thunderstorms of 1888 and 1889." By William Marriott, F.R.Met.Soc. (2) "On the Prevalence of Fog in London during the 20 years, 1871-1890." By Frederick J. Brodie, F.R.Met.Soc.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Typological Museums, as Exemplified by the Pitt Rivers Museum at Oxford." By General Pitt Rivers,

OLD STUDENTS' ASSOCIATION.

8 p.m. Ordinary General Meeting at Finsbury Technical College. Paper to be read: "The Measurement of the Resistance of Conductors containing Disturbing Electromotive Forces, with special reference to Earth Plates." By Mr. Rollo-Appleyard, member.

THURSDAY, December 17th.

CHEMICAL SOCIETY.

8 p.m. Ordinary Meeting. Several Papers will be read.

FRIDAY, December 18th.

PHYSICAL SOCIETY.

5 p.m. Ordinary Meeting. Paper to be read: "On Interference with Alternating Currents." By H. Kilgour.

JUNIOR ENGINEERING SOCIETY.

8 p.m. Ordinary Meeting. Paper to be read: "Engineering Practice in the Cleveland and North-East Coast Districts." By S. H. Wells, Wh.Sc., Stud. Inst. C.E.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Learned Societies in France.—According to statistics published by the Ministry of Public Instruction, there are at the present time 525 learned societies in France, of which 135 have been officially recognised as of national importance. Of these 525 societies, 95 are historical and social; 95 agricultural and horticultural; 57 medical and pharmaceutical; 45 scientific; 41 artistic; 37, geographical, and the rest miscellaneous, including photographic, statistical, and ballooning associations.

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SPECIAL NOTICE.

In **Christmas Week** "THE ELECTRICIAN" *will be* **Published** *on* **Thursday,** *instead of on Friday. Contributions intended for our issue of the 25th inst. must therefore reach the Office not later than Wednesday morning's post.*

Advertisers *will also please note.*

OVERHEAD WIRES AND THEIR WARDENS.

The overhead wire question is a thorn in the side of the electrical industry. Regulations, Acts of Parliament, and bye-laws beset the contractor on every side. Thirteen sections in the Regulations of the Board of Trade for securing the safety of the public and twenty-two bye-laws of the London County Council have to be observed; and the only comfort is that some of these are practically identical, and the others do not appear to clash. The Board of Trade rules, which were issued two years ago, could only take account of "conductors for the supply of energy," as their powers were limited by the Electric Lighting Acts. The bye-laws of the London County Council, under their Overhead Wires Act, deal with all wires, conductors, and cables. Some of them appear to be very stringent, but we understand that they demand little, if anything, more than the self-imposed regulations of the Post Office. The regulations of the Board of Trade were probably the outcome of a scare about imaginary dangers which were threatened by the ugly festoons that disfigured our streets. Public opinion is the true governing principle, and the Board of Trade is its instrument. It was very proper that "regulations for the public safety" should have been drawn up; and, safety being secured, the only other consideration is an æsthetic one. Æsthetic desiderata might have been attained by further rules, *e.g.*, that streets must be crossed only at definite places, at a certain minimum distance apart; and that all wires must be brought to such crossing places, and that the crossing must be at right angles. But, as a matter of fact, if safety be secured, the æsthetic question can well remain in abeyance until many other

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municipal reforms have been accomplished. The Board of Trade, however, seem to have gone further than public opinion demanded. Having drawn up a set of regulations of a character quite unusual with this most practical and sensible of all Government departments, they have decided that overhead conductors can only be permitted as a temporary arrangement in rural districts as well as in large towns. In this country we have no democratic autocrat who, with a stroke of his pen, can order poles to be cut down, throwing a whole city into darkness; we do not hang wealthy citizens from lamp-posts. They do these things in republics. But the Board of Trade, following the traditions bequeathed to them by the author of the first Electric Lighting Act, continue to harass a struggling industry, and JOHN This and TOM That only quietly and by degrees drive capital out of this country.

In the absence of any control, contractors have run riot across the sky with tangled nets of cables, asking or taking way-leave here and there, and caring naught for appearance and but little for safety. This recklessness appears to have reacted in more stringency than is necessary when it is remembered that, but for a solitary accident at Brighton, no mischief whatever has been caused to the public; and this one case would have been amply provided for by reasonable care, to say nothing of the Board of Trade Regulations. To check this jungle-like growth, the Board of Trade drew up their rules, but unfortunately with but little of their usual care and forethought. We have heard that some official, we forget who, promised to some Government department, we forget which, that the working of the Electric Lighting Acts should cost nothing. All expenses would be defrayed by the fees received by the Standardising Laboratory. This condition of affairs may be reached in a few years; but at present it is as idle to expect that an efficient administration can be started on these funds alone, as it would be to hope to conduct a commercial business without a working capital. The magnitude of the electric lighting industry has been greatly under-estimated, and until recently most of the serious work was done by the already hard-worked members of the Railway Department; and even now, with an immense amount of scientific work to be done,, there is but one man, with but one assistant, to do it. A glance at "Whitaker" gives some idea of the highly-experienced and thoroughly competent men who are permanently attached to the other numerous departments of this most important Government office. If the Electrical Department had nothing more to do than the "officers appointed under the Metropolitan Gas Acts" it would still be undermanned, but it has taken upon itself duties the importance of which it apparently does not appreciate.

The bye-laws of the London County Council, which will be found elsewhere in the present issue, need not concern us much at present, though it is hardly necessary to say that we should all feel much more confidence in the Board of Trade if an efficient Electrical Department were organised, and we cannot but regret that so many of its duties are allowed to devolve on this overgrown Vestry. It is to the permanent and technical officials of the London County Council that we owe these rules, and the important movement to determine a standard of light, and it is to them that we look for a well-arranged system of certification. of meters. If they carry out these affairs as well as the Board of Trade would have done, it will not matter if the noisy part of the electorate is a mere turopolegarchy, a word which, in view of the threatened extinction of the Greek language, it may be as well to explain means government by cheesemongers. They dare not make any rules which would trouble the POSTMASTER-GENERAL, and the only matter of concern is the amount of common sense which will be applied in enforcing and interpreting them. Had these rules been made when telephone wires were first flung about among the chimneys the service might have improved more rapidly than it has pone. The nineteenth section has some grounds to support it, since it may be supposed that a "dead" wire will sooner or later give trouble. But do they do so in practice in the case of telephone wires running from an exchange to an office in which the present tenant does not employ a telephone? He, or the next tenant, may become a subscriber; and if a wire is already run up to his window some concession in the matter of rental might be entertained. At all events, to remove such a wire is only throwing away useful work.

To call attention to a point which seems to have been overlooked, and which it is by no means too late to remedy, an address, which we print in another column, will shortly be presented to the PRESIDENT OF THE BOARD OF TRADE. It is of an entirely uncontroversial character, it could not be objected to by the Committee which was consulted by the Board of Trade when the overhead conductor regulations were framed, and it touches a matter of grave importance to everyone who is interested in the development of the electrical industry, viz., the threatened prohibition of all overhead conductors, even in rural districts. This is no Chamber of Commerce matter, the address is dated from Botolph House, because that is the only common ground on which engineers and contractors can meet for such purposes. Copies of the address should find their way into the hands of all responsible men who are engaged in electrical work, and should not be treated as a mere circular, but should be signed and returned at once.

INSTITUTION OF ELECTRICAL ENGINEERS.

At the annual general meeting of the Institution of Electrical Engineers, held last night, the following members of Council were elected for the year 1892 :—

President.

Prof. W. E. Ayrton, F.R.S., President Phys. Soc.

Vice-Presidents.

Alexander Siemens.	Sir David Salomons, Bart., M.A.
R. E. Crompton, M.Inst. C.E.	Sir Henry Mance, C.I.E., M.Inst.C.E

Members of Council remaining in Office.

Major G. W. Addison, R.E.	Colonel R. Raynsford Jackson.
Sir Albert J. L. Cappel, K.C.I.E.	W. M. Mordey.
Sir James Douglass, F.R.S.	Prof. Silvanus P. Thompson, B.A., D.Sc., F.R.S.
Prof. J. A. Fleming, M.A., D.Sc.	
Prof. Geo. Forbes, F.R.SS.(L. & E.)	

New Members of Council.

Edward Hopkinson, M.A., D.Sc., M.Inst.C.E.	Prof. A. B. W. Kennedy, F.R.S., M.Inst.C.E.
Prof. John Perry, D.Sc., F.R.S.	James Swinburne.

Associate Members of Council.

Captain L. A. Beaumont, R.N.	Captain W. C. Hussey, R.E.
M. Cooper.	

It was announced in the course of the reading of the annual report that the Institution Premium had been awarded to Messrs. C. G. Lamb, E. W. Smith, and M. W. Woods, for the Paper on "The Working Efficiency of Secondary Cells," read by them in conjunction with Prof. Ayrton; the Paris Electrical Exhibition Premium being awarded to Mr. J. Swinburne for his Paper entitled "Transformer Distribution; and the Fahie Premium to Mr. P. V. Luke for his communication on the "Early History of the Telegraph in India."

The President also announced that Mr. Nikola Tesla had promised to repeat his high frequency experiments before the Institution in January.

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REVIEWS.

Central Station Management and Finance. By H. H. Foster. (New York: C. C. Shelley. 1891.)

Although this little work will no doubt be of great use to engineers and managers of electric light stations in America, its contents are so directed towards the special style of business and management which is now current in that country, and which is absolutely unknown in England, that its chief interest to the English electrical engineer is to give him some insight into the details of American practice. In England electric lighting supply companies have followed the lead of the gas companies; that is to say, they supply electrical energy at certain terminals in their customers' premises, but they are in no way concerned with anything that takes place beyond this point; that is to say, they have nothing to do with the wiring of the premises other than to test it, and to see that there is no serious leakage. They do not supply or maintain the glow lamps, and very few of the companies have anything to do with arc lamps. Such few arc lamps as are run off the great London stations are in every case the property of the customers themselves, and are maintained, carboned, and repaired by them, or, in some cases, by lamp makers, who take the trouble off their hands, and agree at a contract price to keep the lamps in order and to carbon them. In America the practice appears to differ widely from this. All the arc lamps and most of the incandescent lamps are contracted for at a price per annum; and the whole apparatus connected therewith is installed by the Supplying Company in the first instance, and is afterwards maintained by them. The American Companies, therefore, have very complicated and multifarious duties to perform, and there is no doubt that for such a business a very complete organisation of workshop and storekeeping accounts is absolutely necessary to commercial success. As an aid to such success no doubt Mr. Foster's book will be a valuable contribution. It contains copies of forms, records, returns, and reports relating to circuit and dynamo tests, store-house orders, lamp renewals, and the like. It hardly contains anything of the special subject on which English engineers are anxious for information, viz., the actual working cost of producing the unit of electricity either at the terminals of the dynamo or at the consumer's lamps. The large number of blank forms attached to the book appear to have been thoroughly well thought out; but we think it a pity that they should have been reduced and printed in type of microscopic size—they cannot be read by persons of average eyesight without the use of a powerful lens.

SECONDARY BATTERIES.

BY G. H. ROBERTSON, F.C.S., ASSOC. INST. EL. ENG.

(Continued from page 123.)

The construction of a mould to produce a perforation expanding inwardly is a matter of difficulty, and therefore the grids are sometimes cast in two halves and subsequently joined, as in the Gadot

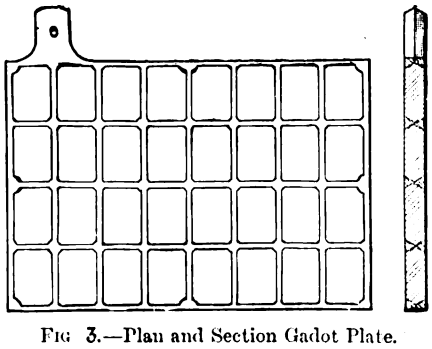

Fig. 3.—Plan and Section Gadot Plate.

cell (Fig. 3). In the Correns cell (Fig. 4), much used in Germany, the grid takes the form of a double lattice.

3. The active material is enclosed in a perforated conducting retaining vessel. In this case also the devices resorted to have been very numerous. Plain or corrugated sheets of lead have been taken and folded into boxes, either before or after applying the paste.

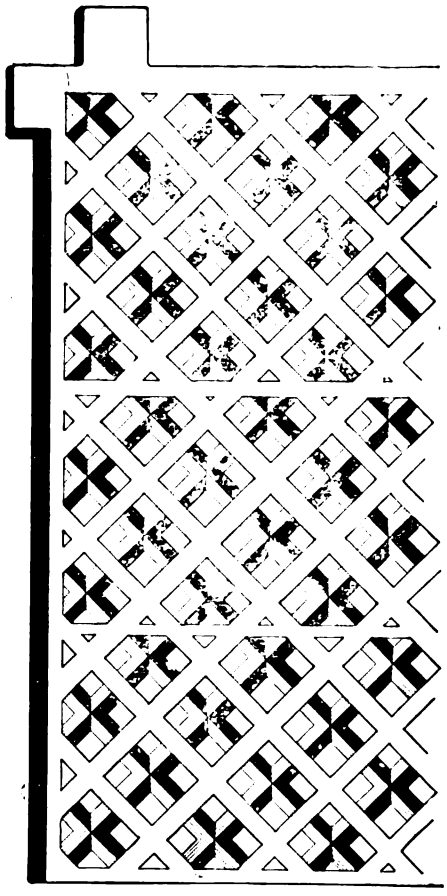

Fig. 4.—Plan Correns Double Grid.

In the Roberts cell (Fig. 5) two grids are taken, pasted on one side, and then united to form a plate with the paste inside (Fig. 6).

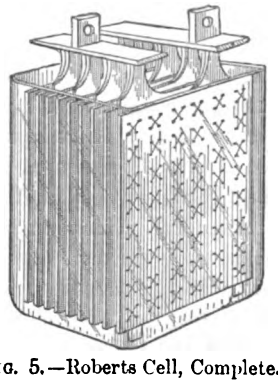

Fig. 5.—Roberts Cell, Complete.

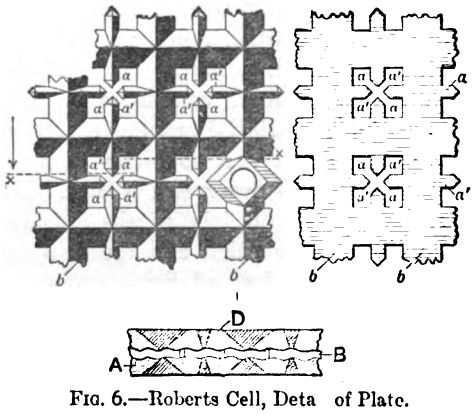

Fig. 6.—Roberts Cell, Deta of Plate.

In Dr. Tommassi's multitubular cell (Fig. 7) the retaining vessel may be constructed of metal, but is usually of some non-conducting material, and so comes under the next heading.

4. The enclosing vessel or plates are made of some non-conducting

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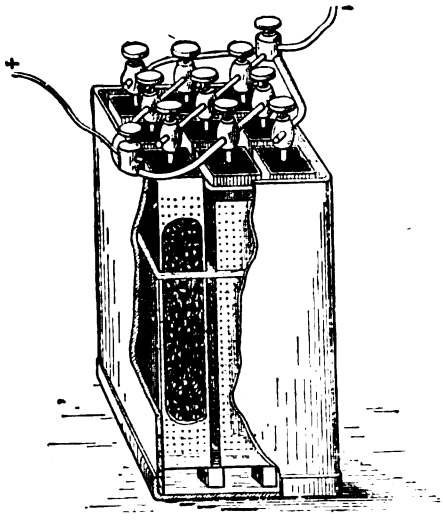

Fig. 7.—Tomassi Cell, corner cut away to show internal arrangement.

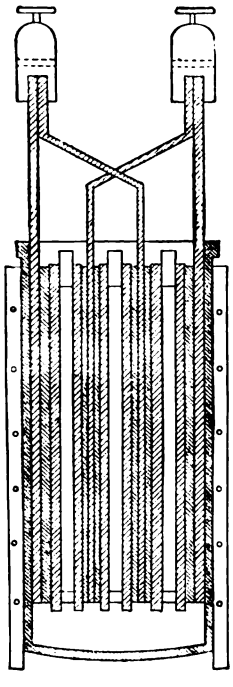

Fig. 8.—Reynier Element, Side View.

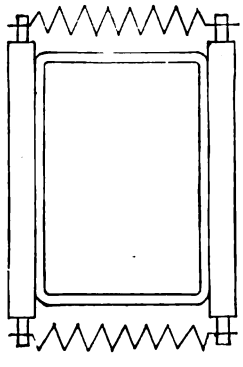

Fig. 9.—Reynier Element, Plan of Compressing Arrangement.

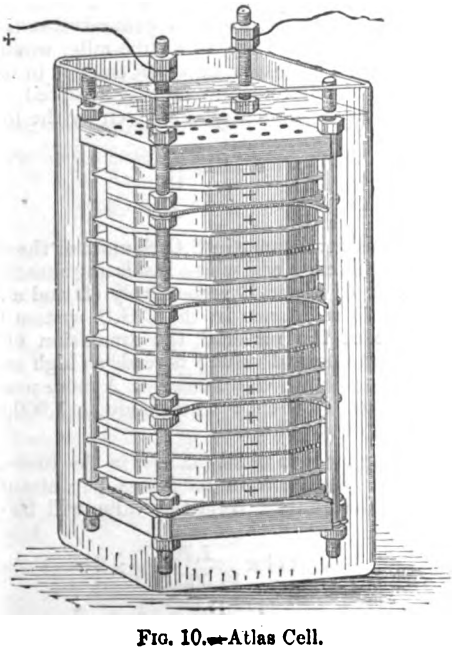

Fig. 10.—Atlas Cell.

material, or some inactive material is packed between the plates to prevent short-circuiting, and retain the active material.*

In France the plates have been covered with perforated sheets of celluloid; Reynier brought out what he called an "elastic cell," specially designed for use on torpedo boats. When tried in 1886 on board "La Gymnote" it was not a success, and the alkaline copper cell was preferred to it. Since then, however, the construction has been much improved (Fig. 8). Each cell, according to improvements effected in 1889, is composed of one positive, two negative plates, and four porous partitions, held together as shown by a frame consisting of two end plates connected together by corrugated strips of metal which have sufficient elasticity to enable them to expand and contract with the alteration in volume of the plates caused by charge and discharge (Fig. 9).

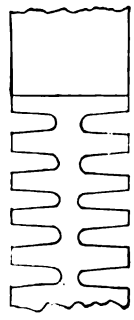

Fig. 11.

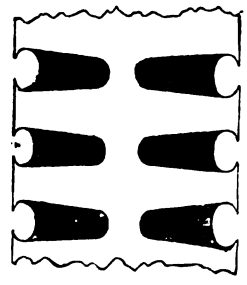

Fig. 12.

Tudor Plate, Side View, Empty.

In this country, Mr. Barber Starkey has tried filling in between the plates with a mixture of plaster of Paris and sawdust; Mr. Fuller uses porous pots; and in the United States, in the Pumpelly battery, cellulose, or wood pulp, is used to separate the plates, which are arranged horizontally as in the Atlas cell (Fig. 10).

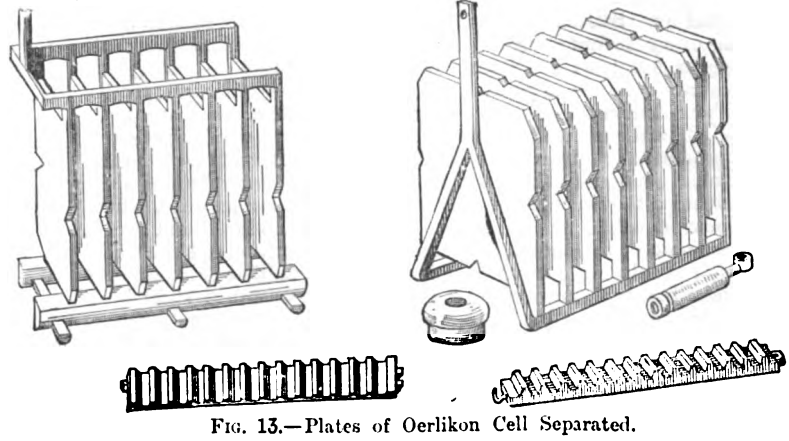

Fig. 13.—Plates of Oerlikon Cell Separated.

B. Improved Connection between the applied Oxide and the Support.—With this object the support has been well rubbed with carbon before applying the paste, and the addition of carbon to the paste in some form has been frequently recommended, as, for instance, kneading the oxides into a paste with lead acetate.

In the Tudor cell (Fig. 11) the positive plates are first treated by Planté's process to coat them with a layer of crystalline electrolytic peroxide; the grooves are then partially filled with a paste of peroxide of lead, and pressure is applied to the ridges to expand them, and partially close the mouths of the grooves (Fig. 12).

The casting or welding of the applied oxide to the plate has also been tried, and to overcome the difficulty of getting the substances to blend into one another caused by the great difference in their melting point, it has been suggested to fill the portion of the mould usually occupied by the support with some reducing agent, such as carbon mixed with nitre, so that when the fused oxides are poured into the mould they will be reduced in part to metallic lead, which will assume the place and shape of the carbon core, while the remainder forms the active material.

General Improvements.

Besides the improvements in what may be called the manufacture of the plates, or electrodes proper, various devices have been resorted to with the view of diminishing the resistance of the lugs,

* The improvements under this heading are equally applicable to cells of the Planté type, but as they are more frequently applied to cells of the Faure type I refer to them under this heading.

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and securing better contact between plates of the same sign, such as making connection by tinned copper rods passed through holes in the lugs. Lead is afterwards cast round the copper, so that it is screened from the action of the acid.

Some attention has also been given to the question of the best electrolyte to use, some advocating the use of acid of density 1,150 to 1,180, while others recommend a density 1,200 and over. The addition of small quantities of some salt of the alkalies, such as sodium sulphate, or carbonate, has been recommended by Mr. Barber Starkey and others with a view of reducing sulphating; and Dr. Paul Schoop has brought out a successful gelatinous electrolyte by adding one volume of dilute sodium silicate, density 1,180, to two volumes of dilute sulphuric acid 1,250.

In order to prevent short-circuiting between the plates by the material dislodged in working, they are now either slung or rest on supports, which are so placed that the formation of a layer of mud between them is prevented.

The equalisation of the chemical action over the surface of the plates has also been attempted, and in the Schoop cell the current enters at the top of one set of plates, and leaves from the bottom of the others. The plates also are widely spaced now, as a rule, the proportion of acid to plates has been increased, and little alterations are constantly being made to secure the free circulation of the electrolyte essential to regular working.

(To be continued.)

ON THE SPECIFICATION OF INSULATED CONDUCTORS FOR ELECTRIC LIGHTING AND OTHER PURPOSES.*

BY W. H. PREECE, F.R.S., PAST-PRESIDENT.

It cannot be said that we have hitherto been happy in our mode of specifying the insulating properties of electric light cables and conductors. Standards of quality and modes of classification differ with every manufacturer. The practice of the submarine cable engineer has been continued by the electric light engineer, and cables are specified to give so many megohms per mile, irrespective of their dimensions or of the purpose to which they are to be applied; while efforts are rarely, if ever, made to verify the figures so prominently given in published tables. If tests were made, it would be found that if the results were true for one-sized conductor, they would be absolutely untrue for another. In a submarine cable, or in insulated wires for underground work, telegraphic or telephonic, the size of the conductor and the thickness of insulating coating remains constant, so that it is perfectly permissible to specify that the insulation resistance shall be x megohms per mile; but in electric light leads the diameters vary in every part of a building; a continuous mile length is rarely or never used except in mains and feeders, and the same mode of specifying is meaningless. Moreover, it is wrong; for if a conductor of 1mm. diameter gave an insulation resistance of 2,000 megohms per mile when covered with an insulator 1mm. thick, a conductor of 10mm. diameter covered to the same thickness would give only 332 megohms per mile, yet its efficiency would be the same; while, if it were constructed to give uniformly 2,000 megohms per mile, it would be absurdly constructed and wastefully paid for.

In designing an electric light lead we have to regard the insulating quality of the material to be used, and the potential differences it has to resist. Its mechanical merits we will neglect for the present. The quality of the material can be defined without reference to its form; and if it be, as it ought to be, of a uniform and consistent material, we want to know simply its *specific insulation* or its resistance to the passage of currents through it when subjected to potential differences.

Specific Resistance.

The specific resistance (ρ) of conductors is thoroughly well known. The standard of reference is the resistance of a centimetre cube of some imaginary metal whose resistance is one C.-G.-S. unit of resistance at 0 C. 1,000,000,000 (10^9) cm. of this imaginary metal 1cm.^{2} section give an ohm.

Divide 10^9 cm. by ρ, and we obtain in any metal the length in cm. of 1 cm.^{2} sectional area giving 1 ohm. Thus $\frac{10^9}{1,580} = 632,911$ cm. of soft copper of that section, and this divided by 30·48 = 20·764·8 feet, or 6,921·6 yards, which give *one ohm.*

Again, $\frac{10^9}{94,070} = 10,630$ cm. of mercury of 1 cm.^{2} section, or 106·3 cm. of 1 mm.^{2} give 1 ohm.

* Paper read before the Institution of Electrical Engineers, December 10, 1891.

The following table shows the specific resistance of various metals, together with their temperature coefficients :—

	Specific resistance.	Temperature coefficient per 1° C.
Silver	1,488	·0377
Copper (soft)	1,580	·00388
„ (hard)	1,616	·00388
Gold	2.036	·0C388
Aluminium	2.881	·0039
Zinc	5.566	·00365
Platinum	8.957	·0034
Iron	9.611	·0048
Nickel	12.300	—
Tin	13,070	·00365
Lead	19.420	·00387
German silver	20,710	·0C344
Platinum-silver	24,120	·00031
Platinoid	32.907	·00022
Nickel-steel	78.080	·0C093
Mercury	94,070	·C0086

This table also implies that if we take a length of 10^9 cm. of any metal of 1 cm.^{2} section the number (ρ) indicates the resistance of that length in ohms. Thus, 10^9 cm. of soft copper of that section gives 1,580 ohms.

Conductivity in submarine cables (of the Post Office standard type) is specified as follows:—"Each conductor shall be formed of a strand of seven copper wires, all of equal diameter, shall weigh 107lbs. per nautical mile, and shall at a temperature of 75° F. have a resistance not higher than 11·65 ohms or lower than 11·18 ohms per nautical mile."

The limits of resistance are defined in order to maintain the weight of the copper of the coils within a proper margin, and to secure the proper proportion between the metal and the dielectric. Improvement has recently taken place in the purity of the copper manufactured; the density is greater, and as a result we obtain coils which with our present mode of testing give a better result than that of Matthiessen's standard of pure copper. Coils giving 101 per cent. of pure copper are frequent, and 102 per cent. not uncommon. The manufacturers are prepared to supply pure copper; we therefore intend to abolish the percentage clause, and to abandon specifying anything but pure copper. But we must determine its specific gravity, for it appears clear that the high conductivity is due to greater density, and there is no reason to doubt the accuracy of Matthiessen's determination of the specific resistance of pure copper at a density 8·90.

Specific Insulation.

The specific resistance of insulating materials is not so well known as that of conductors, and is very variable. Clark and Sabine (1871) adopted as a standard the resistance of a cube-knot of the insulator at 75° F. (24·2° C.). But this standard never came into use, though it was tacitly admitted in all calculations derived from cylindrical cores, using the knot as unit length, and it was confined solely to submarine cables. The *knot* itself is an improper term, for a knot is a velocity, and not a length. The proper term is a nautical mile (2,029 yards) abbreviated into *naut*. Now a knot is a "naut" per hour, and is a term confined to a class. Hence its use in any form as a general standard is out of the question. A cube-kilometre, or a cube-mile, would be a more convenient unit, but a cube-quadrant (10^9 cm.)^3 is in harmony with our C.G.S. system of units now universally accepted. The *specific insulation* of any insulating material is given by the formula,

$$\sigma = \frac{\rho l 2\pi}{\log_\epsilon \frac{D}{d}}$$

where ρ is the specific resistance in C.G.S. units of the dielectric of a cable whose length is l cms., and whose insulating sheathing has inner and outer diameter of d and D respectively (D and d being in any units). The specific resistance in the C.G.S. system being that of a cubic centimetre of the material, the dimension of such a unit gives an excessive numerical value; it reads as high as 10^{25}, C.G.S. unit—a figure beyond our comprehension. A more practical dimension is the resistance of a cube whose side is 1,000,000,000 (10^9) centimetres, taken in megohms.

Since in this country it is usual (except in the case of submarine cables) to express insulation in megohms per statute mile, the specific insulation determined from this value will be given by the expression,

$$\sigma = \frac{R \times \cdot 9144 \times \frac{1,760}{10,000,000} \times 2\pi}{\log_\epsilon \frac{D}{d}};$$

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or, giving 2π its numerical value and substituting common for natural logarithms, we get the expression,

$$\sigma = \frac{R \times 4{\cdot}39}{\log \frac{D}{d}} \div 10{,}000,*$$

where R is the insulation resistance in megohms per statute mile.

The practical standard, then, of specific insulation which I propose to adopt is the resistance of an earth quadrant (1,000,000,000 centimetres) cube of a certain insulating material which at 0° C. gives a resistance of 1 megohm.

In this sense the specific insulations (σ) of various materials, calculated from dimensions and resistances, but not corrected for temperature: are as follows:—

Material.	C.G.S. units.	Proposed standard. (σ)	Temperature. ° C.	Authority.
Air	∞	∞	—	—
Mica	$8{\cdot}4 \times 10^{22}$	·084	20	Ayrton & Perry.
Gutta-percha	$4{\cdot}5 \times 10^{23}$	·45	24	L. Clark.
India-rubber	$1{\cdot}09 \times 10^{25}$	10·9	24	—
Shellac	$9{\cdot}0 \times 10^{24}$	9	23	Ayrton & Perry.
Hoopers' core	$1{\cdot}5 \times 10^{25}$	15	24	Tests.
Ebonite	$2{\cdot}8 \times 10^{25}$	28	46	Ayrton & Perry.
Paraffin	$3{\cdot}4 \times 10^{25}$	34	46	" "
Glass (Flint)	2×10^{25}	20	20	T. Gray.
Siemens' special high insulating rubber	—	16·17	15	—
Siemens' ordinary pure and vulcanised rubber.	—	2·28	15	—
Siemens' specially high insulating fibrous material	—	11·60	15	—
Fowler-Waring dielectric	—	7·33	15	—
Glover vulcanised rubber	—	1·63	15	—

To obtain the true value for σ, these results, of course, ought to be corrected to 0° C.

* A simple approximation to this formula has been worked out by Mr. H. R. Kempe as follows:—

$$\text{Log}\epsilon \frac{D}{d} = 2\left\{\frac{D-d}{D+d} + \frac{1}{3}\left(\frac{D-d}{D+d}\right)^3 + \frac{1}{5}\left(\frac{D-d}{D+d}\right)^5 + \ldots\right.$$

Now, if D and d do not differ largely, we may neglect all the terms after the first without considerable error; so that the expression,

$$\frac{\rho\, l\, 2\pi}{\log\epsilon \frac{D}{d}}$$

becomes

$$\frac{\rho\, l\, \pi}{\frac{D-d}{D+d}};$$

or, substituting thickness, t, of material, we get,

$$\rho\, l\, \pi \cdot \frac{d+t}{t}.$$

Inserting the numerical value of π, and making R the resistance per statute mile, we have,

$$\sigma = R \times 5{\cdot}0559 \times \frac{d+t}{t} \div 10{,}000,$$

which may be written approximately (especially since we know that $\frac{d+t}{t}$ is actually rather too large)

$$\sigma = R \times 5{\cdot}05 \times \frac{d+t}{t} \div 10{,}000.$$

For general purposes the expression,

$$R \times 5 \times \frac{d+t}{t} \div 10{,}000,$$

or

$$\frac{R \times \frac{d+t}{t}}{2{,}000},$$

will give sufficiently correct results, being within 1 per cent. of accuracy in most cases. Thus, taking D = ·5, d = ·314, R = 5,000 (the actual results obtained with a rubber insulated wire), then t = ·093: by the exact formula we have,

$$\sigma = \frac{5{,}000 \times 4{\cdot}39}{\log{\cdot}5 - \log{\cdot}314} \div 10{,}000 = \frac{5{,}000 \times 4{\cdot}39}{\bar{1}{\cdot}6989700 - \bar{1}{\cdot}4969296} \div 10{,}000 = 10{\cdot}865.$$

By the approximate formula we get,

$$\frac{5{,}000 \times \frac{{\cdot}314 + {\cdot}093}{{\cdot}093}}{2{,}000} = 10{\cdot}941.$$

Electrification.

Insulated conductors should always be subjected to the process of electrification for one minute before the scale reading from which the insulation is to be calculated is noted. The leakage current polarises the dielectric; the insulation apparently improves—rapidly at first, then more slowly—and unless some conventional time were agreed upon for the test, proper comparisons could not be made. One minute is universally accepted as the period. The rate of fall due to electrification is a great test of the quality of the insulating material. It varies with the nature and quality of the material, being more marked at low temperatures. Unsteady electrification is a sign of an incipient fault, and perfectly irregular electrification is an indication of good material. The resistance of the dielectric apparently gradually increases, owing to the formation of an opposing electro-motive force in what is probably a liquid electrolyte. As the rate at which electrification proceeds is an uncertain quantity, and in the best material is very low, it is better to specify that the electrification shall progress steadily, without stating the rate at which it proceeds. The temperature at which the test is to be made should also, of course, be given, 75° being the usual standard.

Thickness of Insulation.

More important is it to determine and specify the thickness of the insulating coating. Two conditions determine this—the E.M.F. to be used, and the mechanical conditions of manufacture. We have also to consider sparking distances in air, especially in the case of high-pressure mains, when heat, age, accident and use cause decay and cracks, and the conductor becomes exposed through fissures. I cannot contemplate a less thickness of any material than 1 millimetre, or ·04 of an inch, for a No. 19 wire. That means that a millimetre conductor requires as a minimum a millimetre thickness of insulating coating. Now, the striking distance of a millimetre in air is over 600 volts. As the conductor increases in diameter the thickness must increase in greater ratio, not because the E.M.F. requires it, but because the exigencies of manufacture and the mechanical construction of the core demand more stuff to resist the stresses brought to bear upon it. Given a conductor with a certain thickness of dielectric able to resist the stress of x volts, the same thickness will equally resist the same voltage whatever the diameter or sectional area of the conductor.

The actual thickness to be used above the crucial thickness required for the security of those who accidentally or purposely handle the wire depends, of course, on the specific insulation, and the higher this is the less need the thickness be, and the less the mass of material used. This is a manufacturer's question; the engineer can specify only the minimum thickness. The Board of Trade rule for aerial conductors is the following:—

"Every high-pressure aerial conductor shall be continuously insulated with a durable and efficient material, to be approved by the Board of Trade, to a thickness of not less than one-tenth part of an inch; and in cases where the extreme difference of potential in the circuit exceeds 2,000 volts, the thickness of insulation shall not be less in inches or parts of an inch than the number obtained by dividing the number expressing the volts by 20,000. This insulation shall be further efficiently protected on the outside against injury or removal by abrasion, If this protection be wholly or partly metallic, it shall be efficiently connected to earth.

"The material used for insulating any high-pressure aerial conductor shall be such as will not be liable to injurious change of physical structure or condition when exposed to any temperature between the limits of 0° and 150° Fah., or to contract with the ordinary atmosphere of towns or manufacturing districts."

The two points, then, to be met are those of specific insulation and of thickness; the former determining the quality of the material, and the latter being governed by the striking distance.

It is an extremely difficult thing to arrive at a definite conclusion as to the exact sparking distance across an air space with a given potential difference. It varies with the character of the opposing surfaces; with the resistance, capacity, and electro-magnetic inertia in the circuit; with the nature of the current—that is, whether it is steady or alternating, and also in the latter case with the frequency. Sir W. Thomson concludes "that a Daniell's battery of 5,510 elements can produce a spark between two slightly convex metallic surfaces at one-eighth of a centimetre asunder in ordinary atmospheric air" ("Papers on Electrostatics and Magnetism," page 259), which means that it requires 4,928 volts to strike across one millimetre.

Warren de la Rue obtained a result very similar. Prof. Crookes, using an induction coil, takes much lower figures, and estimates the striking E.M.F, at 1mm. as 920 volts. Mr. Ferranti, using a frequency of 200, and 20,000 volts, brought the voltage down to 620.

I propose for underground and covered conductors to specify as a minimum for 500 volts or any E.M.F. under 1mm. thickness of dielectric, and ·5mm. for each succeeding 500 volts or portion of 500 volts. Thus we should have, for—

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Thickness of Dielectric for different Voltages.

Voltage.	mm.	Inch.	Board of Trade inch.
500 and under	1·0	·04	·04
1,000 „	1·5	·06	·05
1,500 „	2·0	·08	·075
2,000 „	2·5	·10	·10
* 2,500 „	3·0	·12	·125
* 5,000 „	5·5	·22	·25
*10,000 „	10·5	·42	·5

* Material of superior quality *i.e.* σ over 10.

Classification.

The classification of insulated conductors is most varied and perplexing as regards the dielectric. The most systematic method is that of Siemens as regards the conductor. The pattern number gives the length in yards which has a resistance of one-tenth of an ohm; divided by 4, it gives its carrying capacity in amperes; divided by 5, it gives its weight in lbs. per mile; divided by 6, it gives its sectional area in mm²; divided by 4,000, it gives its sectional area in square inches. Nothing can be more charming. But when we come to insulation we have types G, H, J, P, Q, R, L, M, N, LL, MM, NN, LLL, MMM, and NNN—all differing in the number and thickness of layers of pure rubber, of vulcanised rubber, of "special prepared material," in taping, braiding, preserving with compound, lead, tarred jute yarn, and iron sheathing, and also in insulation resistance per statute mile in megohms at 60°.

N, NN, and NNN, are intended for 250, 2,500, and 5,000 volts respectively, and they vary in price in the ratio, 64, 79, 93.

We are, however, told that they are tested in water *when not intended for dry places*, and Messrs. Siemens show that the insulation resistance diminishes as the size of the conductor increases.

For instance, type R: "Insulated with one layer of pure and two of vulcanised rubber, taped (braided and drawn through preservative compound). Tested under water, insulation resistance from 2,000 to 700 megohms per statute mile at 60° F., according to size of wire." The words in brackets form the sole difference between types J and R!

The Silvertown Company work up by areas of conductors, advancing by twentieths of a square inch, between $\frac{1}{10}$th square inch and 1 square inch. The insulator is composed of pure rubber—their best vulcanised india-rubber. They used to endeavour to maintain a constant ratio of diameters of conductor and dielectric, but the insulation resistance now varies with size. The wires are all rigidly tested under water, and give over 2,500 megohms per mile.

But the classification into letters is as perplexing as with nearly all the other makers, except, perhaps, the Fowler-Waring Company, who have only one dielectric and one form of protection, viz., lead covering.

The Standard Underground Cable Company of U.S.A., who use Waring's compound, specify the thickness of insulation in mils. Their smallest is 31 mils., 9 mils. less than the proposed minimum. Their thickest is 188 mils., or 7·5mm., which is good enough for 7,000 volts.

This classification into types is a manufacturer's question. We cannot interfere with it, but we do earnestly hope that they will study the convenience of the user by reducing their types to the lowest possible number, but, above all, by removing from their lists the cheap and nasty.

The evil of this loose system was strikingly exemplified in a case which recently came before the law courts, when some of the ablest counsel were busily employed for several hours in endeavouring to explain what was meant by "C" quality wire, with but little result, none of the expert witnesses present being able to throw any light on the subject.

I am much indebted to different firms for the information which they have cheerfully given me to enable me to comprehend the classification, and to determine the specific insulation of the different materials they use; and as this information may be very useful, I tabulate it, and submit it herewith.

Specification.

The consulting engineer can afford to smile at classification, for he can draw up his own specifications, but it is extremely difficult even to do this without a reference to some well-known maker's class.

No wire should ever be used which cannot be subjected to a test under water. Insulated wire is supplied which is specified *to be used in dry places only*. But as this stuff is cheap, inspection is ignored, and dry places are not always dry; its general use follows: dampness and leakage result, electrolysis sets in, and the conductor is eaten away, if it is not charred or even set on fire.

It is impossible too speak too strongly on the terrible abuse of ordinary precautions which is encouraged by the manufacture of

Specific Insulation (σ) of Electric Light Cables manufactured by various Firms.

Manufacturer.	Conductor. No. of wires & approximate gauge.	Conductor. Diameter. in.	Conductor. Diameter. mm.	Dielectric. Thickness (t). in.	Dielectric. Thickness (t). mm.	Dielectric. Diameter (D). in.	Dielectric. Diameter (D). mm.	Insulation per mile at 60°F. Megohms	Specific insulation (σ)	Remarks.
Siemens Brcs.	7/22	·084	2·11	·076	1·93	·236	5·99	16,180	15·84	Insulated with "Siemens' special" high insulating india-rubber.
„	„	„	„	·078	1·98	·240	6·10	18,270	17·60	
„	19/15½	·340	8·64	·079	2·03	·501	12·72	1,022	2·67	Ordinary pure and vulcanised rubber.
„	61/15½	·612	15·54	·168	4·27	·949	24·10	824	1·90	
„	51/12	·850	21·59	·190	4·82	1·230	31·24	4,082	11·17	Lead-cased; insulated with specially high insulating fibrous material. (Bradford Corporation mains.)
„	37/13	·651	16·53	·096	2·44	·844	21·43	2,567	10·00	
„	19/14	·410	10·41	·079	2·01	·568	14·42	3,794	11·77	
„	7/13	·286	7·26	·079	„	·444	11·28	6,389	14·69	
„	60/6½	1·656	42·06	·113	2·87	1·882	47·80	624	4·93	Lead-cased; insulated with impregnated fibrous material. (St. James's and Pall Mall Co.'s mains.)
„	„	„	„	„	„	„	„	830	6·56	
„	60/10	1·170	29·72	·114	2·89	1·398	35·51	851	4·83	
„	„	„	„	„	„	„	„	1,014	5·76	
Silvertown	19/15	·360	9·14	·144	3·66	·648	16·46	6,763	11·64	Insulated pure india-rubber, then vulcanised india-rubber.
„	„	„	„	„	„	„	„	6,664	11·46	
„	„	„	„	„	„	„	„	6,549	11·25	
Callender	7/16	·192	4·88	·154	3·91	·500	12·70	380	·40	Insulated with vulcanised bitumen.
„	19/18	·240	6·10	·155	3·94	·550	13·97	400	·49	
Glover	19/13	·460	11·68	·115	2·92	·690	17·52	600	1·50	Insulated pure and vulcanised rubber.
„	„	„	„	„	„	„	„	515	1·28	
„	„	„	„	„	„	„	„	560	1·40	
„	7/16	·192	4·88	·055	1·40	·302	7·67	855	1·91	
„	„	„	„	„	„	„	„	813	1·81	
„	„	„	„	„	„	„	„	833	1·86	
Fowler-Waring ...	1/18	·048	1·22	·036	·91	·120	3·05	6,522	7·20	Waring compound.
„ ...	1/16	·064	1·62	·043	1·09	·150	3·81	6,619	7·85	
„ ...	7/16	·192	4·88	·078	2·03	·352	8·94	4,835	8·07	
„ ...	19/18	·240	6·10	„	„	·400	10·16	3,280	6·48	
„ ...	19/16	·320	8·13	·095	2·41	·510	12·95	3,312	7·18	
„ ...	19/15	·360	9·14	·100	2·54	·560	14·22	3,145	7·19	
Henley	1/10	·128	3·25	·046	1·17	·220	5·59	564	1·05	Insulated with pure and compound india-rubber.
„	7/16	·192	4·88	·054	1·37	·300	7·62	406	0·92	
„	19/18	·240	6·09	·060	1·52	·360	9·14	329	0·82	
„	1/14	·030	2·03	·040	1·02	·160	4·06	4,440	6·48	Ozokerited india-rubber.
„	3/30	·078	1·98	·039	·99	·157	3·99	5,240	7·57	
„	7/15	·216	5·49	·057	1·45	·330	8·38	2,210	5·27	
„	19/14	·400	10·16	·080	2·03	·560	14·22	2,000	6·01	
„	61/15	·648	16·46	·111	2·82	·870	22·09	2,200	7·55	
„	61/12	·936	23·77	·217	5·51	1·370	34·79	7,146	19·98	Special cable—Class AA.

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these cheap cables. It destroys confidence, introduces danger, and discourages the industry.

A very curious practice has recently developed itself among our wiring contractors. They have asked manufacturers to reduce the over-all diameter of their insulated conductors in order to enable them to utilise the grooved boarding which they happen to have in stock. In other words, the interests of the users of the electric light are to be sacrificed to the interests of the wood-carvers!

I do not believe in danger to person in high-pressure systems when proper material is used. They are so safeguarded that any contact between primary and secondary—practically the only source of danger—leads at once to safety. I fear more danger of fire in both systems, and this more in low-pressure systems than in high-pressure ones, for they are not so safeguarded and are more open to abuse. In fact, the numerous accidents that have occurred from imperfect work on low-pressure systems has already attracted serious attention to its dangers.

I prefer, then, to specify that—

1. The copper must be pure, and such that at a density of 8·9 its specific resistance is 1,616; that is, it must comply with Matthiessen's standard of pure hard drawn copper.

2. If it is to be covered with any vulcanised material, it must be *tinned*.

3. No size smaller than No. 19 (·04in. or 1 mm. wire) is to be used.

4. No single single wire greater than No. 16 is to be used.

5. All larger sizes are therefore to be stranded.

6. The weight of copper used is to be such that the loss of volts between the distributing switch and the furthest lamp when full load is on shall not exceed 1 per cent. Hence the current which each conductor has to carry must be given.

7. The dielectric to be employed must be described, with its specific insulation, in terms of a quadrant-cube of gutta-percha at 75deg., which is taken as unity.*

8. The thickness of dielectric must be given for the different sized conductors used.

9. The various modes of preserving and protecting the insulated cables must be given.

10. Every coil should have attached to it the maker's certificate, testifying that it complies with this specification, and that it has been tested under water.†

Testing.

There are upwards of 130,000 miles of cable submerged in the ocean, and I cannot recall to mind a single fault that has occurred since 1865 through a manufacturer's defect that has escaped the probe of the tester. Every cable is most rigidly and carefully tested under water. Why do not users do the same with their electric light conductors? It would be the greatest safeguard for security.

There is a widespread impression that the insulation varies inversely with the potential differences employed, and that the higher the voltage used the more accurate the result. This is a mistaken notion. The following experiment was made to show its fallacy:—

Table showing Results of Insulation Tests of Gutta-Percha Core with various Voltages.

Number of cells. (Leclanché).	Galvanometer readings. 1st min.	2nd min.	3rd min.	Insulation after 1 minute's electrification.
				Megohms.
10	18½	16	14½	164·3
40	76	67	64	162·2
100	179	163	157	173·3
200	181 7,000 ω	168	162	168·2
300	192 4,000 ω	181	177	172·2
400	188 3,000 ω	177	173	174·1

The advantage of high voltage is that it breaks down incipient faults; but, on the other hand, if too high, it may put in faults; it is therefore advisable that the insulation be tested with a voltage, say, not less than 50 per cent., and not more than 100 per cent. above the voltage it is intended to resist.

* This can easily be deduced from its insulation in megohms per mile when the dimensions and the temperature coefficient for the material are given.

† Messrs. W. T. Glover and the Silvertown Company already do this.

THE LONDON OVERHEAD WIRES ACT, 1891.

COUNTY COUNCIL BY-LAWS.

At the meeting of the London County Council, on December 1st, the Highways Committee submitted a report containing a set of by-laws drawn up in pursuance of the London Overhead Wires Act of 1891. These by-laws, which were approved by the Council on Tuesday last, are as follows:—

In these by-laws the expression "Company" includes person. The expression "wire" includes any wire conductor or cable, any part of which is placed, or shall hereafter be placed, over any street or any part of any street, and also any wire conductor or cable placed, or intended to be placed, on or over any building or land, and situate at any point within a distance of 50ft. from any street, but shall not include any such wire conductor or cable which is placed, or may be placed wholly upon or over any railway or any land belonging to a railway company and used as a railway station, siding, or yard, or any part of any such wire conductor or cable being upon or over any railway or such land. The expression "cable" includes any covered or insulated wire when the thickness of the covering or insulation exceeds the diameter of the wire, and any number of insulated wires combined in one cable, whether stranded or separate.

1. Within three months after the approval of these by-laws by the Board of Trade, every Company owning or using or claiming power to use any wire or wires existing at the date of such approval shall, for the purpose of registration and identification, deliver to the Council and to the Local Authority in whose district the same are situate (upon a form to be obtained from the Council), full particulars of all such wires, the particulars to be accompanied by a plan showing the routes of the wires, and to give full information as to material of wires and supports, gauge of wires, mode of support, giving dimensions of poles, stays, and other supports and attachments, position of each support, date of erection and of last renewal (if any).

2. Any Company proposing, after the approval of these by-laws, to erect any wire, or any support or attachment thereto, shall, not less than 14 days before the work is commenced, deliver to the Council and to the local authority in whose district the same are situate (upon a form to be obtained from the Council) full particulars thereof, the particulars to be accompanied by a plan showing the route of the wire, and to give full information as to—material of wire and supports, gauge of wire, mode of support (giving dimensions of the poles, stays, and other supports and attachments), position of each support; and no wire support or attachment shall be erected otherwise than in accordance with such particulars and information.

3. No post or support for any wire shall be placed or erected in any street without the previous consent in writing of the Local Authority.

4. No wire shall at any point be at a less height above the ground than 20ft., or where it crosses a street 35ft., or at a less height above any building than 7ft., except where brought into any building for use in such building, or when attached to chimneys, or other parts of buildings in accordance with these by-laws.

5. Every wire shall be supported at intervals not exceeding 115 yards, unless permission in writing be obtained from the Council and the Local Authority for a longer span, but in no case shall the distance between supports exceed 140 yards.

6. Where any wire crosses a street the angle between the wire and the direction of the street at the place of such crossing shall not be less than 60 degrees.

7. Every support for a wire shall be of durable material, and properly stayed against forces due to wind pressure, change of direction of the wires, and unequal length of span; and all wires, whether conductors or suspending wires, shall be securely attached to the supports, and shall be shackled off at each support.

8. The factor of safety for all conductors and suspending wires shall be at least five, and for all other parts of the structures at least ten, taking the maximum possible wind pressure at 50lb. per square foot. No addition need be made for a possible accumulation of snow.

9. Every support for a wire shall be marked to the satisfaction of the Council in such manner as to enable inspectors to know at once to what Company it belongs. Every new support for a wire shall also have the date of erection marked thereon.

10. No support for a wire which carries more than 10 wires shall be used for the wires of more than one Company, and no support carrying fewer than that number shall, without the previous consent in writing of the Council and the Local Authority, be used for the wires of more than one Company.

11. No single support for a wire shall be used for more than 20 wires without the consent in writing of the Council and the Local Authority.

12. Cables (where used) shall be carried by independent suspending wires and attached to the same by efficient slings; no cable shall exceed one inch outside diameter and one pound per lineal yard in weight.

13. All iron or steel wires and all iron or steel supports or attachments shall be galvanised.

14. All poles supporting wires erected on buildings shall be carried on properly galvanised iron shoes and saddles, and efficiently stayed, so that in the event of a pole breaking, it shall be impossible for it to fall into any street.

15. Every support for a wire if of metal shall be efficiently connected to earth, and if of non-conducting material, shall be protected by a lightning-conductor, fastened to the support along its entire length, and projecting

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above it to a height of at least 6in., such lightning conductor being efficiently connected to earth.

16. Where a wire is attached to any wall, chimney, or similar erection, a suitable angle-plate or other suitable device of iron securely fixed shall be used.

17. Every wire, together with its supports and all structural parts belonging to or connected with it, shall be duly and efficiently supervised and maintained by the Company to which it belongs.

18. No wire, support, or attachment shall or may be in such a condition that danger to the public using the streets may be apprehended therefrom; and the Company to whom such wire, support, or attachment which is in such a condition belongs, shall be guilty of an offence against these by-laws.

19. No wire or support or attachment thereto shall remain erected for more than one month after it has ceased to be in use unless the Company intend within a period not exceeding three months to take it again into use and of such intention shall give notice to the Council and the Local Authority.

20. Every Company shall give or secure access at all reasonable times for the purpose of the inspection and examination of any wire, support or attachment, and other apparatus used in connection therewith, to the Council and the Local Authority, their officers and servants.

21. Any Company which shall erect or cause to be erected any wire, support, or attachment, otherwise than in accordance with, or shall fail to comply with or shall act contrary to, any of the requirements of the foregoing by-laws, or shall deliver to the Council or the Local Authority pursuant to these by-laws any incorrect particulars or information, shall be deemed to have committed an offence against the same, and shall be liable for every offence to a penalty of ten pounds, and in case of a continuing offence to a further penalty of forty shillings for each day after conviction, provided, nevertheless, that the Justices or Court before whom any complaint may be made, or any proceedings may be taken in respect of any such offence, may, if they think fit, adjudge the payment as a penalty of any sum less than the full amount of the penalty imposed by this by-law.

22. Nothing in these by-laws shall extend to any wire placed by any person for his private use over land belonging to him or in his occupation which does not extend over any street, and is so constructed and placed that neither the wire nor any support thereof or attachment thereto would be liable to fall into any public street.

THE ELECTRIC LIGHTING ACTS, 1882 AND 1888, AND OVERHEAD WIRES.

The following important circulars have been sent out by the Electrical Trade Section of the London Chamber of Commerce :—

DEAR SIRS: We enclose four copies of an address to the President of the Board of Trade, in consequence of that Department having recently addressed several firms engaged in electric contract work, informing them that overhead wires will in no case be allowed as a permanency. If you agree, as we think you will, in the reasonableness of the requests set forth in the address, we shall be glad if you will sign and return a copy on behalf of your firm, and further obtain the separate signatures of as many of the members and *employés* of your firm as are of standing in the electrical or engineering profession. It would be well that such of the signatories as belong to scientific institutions or societies denote the fact by attaching the usual letters after their names. We shall be glad to supply you with further copies of the address if required.—Yours faithfully,

R. E. CROMPTON (Chairman Electrical Trade Section).
KENRIC B. MURRAY (Secretary).

December 1 1891.

ADDRESS

To The Right Honourable Sir MICHAEL HICKS-BEACH, Bart., M.P.,
President of the Board of Trade, Whitehall, S.W.

"SIR,—We, the undersigned, electrical engineers, electrical contractors, and others interested in the distribution of electrical energy, have the honour to address you on the subject of the Electric Lighting Acts of 1882 and 1888, and desire respectfully to submit to you the following observations on the subject of the use of overhead conductors in rural districts.

"We are aware that in the case of the metropolis and of large towns your Department has already decided that overhead conductors can only be permitted as a temporary arrangement, and that all permanent conductors must be laid underground. Whilst we are of opinion that that decision may even yet have to be reconsidered in the light of subsequent experience, we are anxious to make it perfectly clear that in this communication we have no wish to question the correctness of that decision, but we desire to emphasise the fact that a marked distinction exists between undertakings which are to be carried out in the metropolis, in large cities or towns, and undertakings in small provincial towns or rural districts; and we beg leave to submit that, however cogent may be the reasons which have led your Department to decide against overhead conductors in large towns, such reasons do not apply with the same force in small towns or in rural districts. The objections to overhead conductors, based upon the inconvenience to traffic and the danger to life, are, in the country, far less serious, if not altogether absent; whilst, on the other hand, the advantages which such conductors afford are greater.

"As regards the safety of the public—a consideration to which, as we are aware, your Department is always bound to attach the utmost importance—we would submit that absolute prohibition of the use of overhead conductors is not necessarily consistent with increased security to the public. When overhead conductors are erected in conformity with well-considered regulations, and under proper supervision, the possibility of danger resulting from their use is so remote that it may be disregarded in view of the advantages gained. It may, in fact, be less than would be occasioned by the use of the underground mains.

"With regard, on the other hand, to the advantages which are offered by overhead conductors, we would point out that in the case of small towns and rural districts the probable consumers of electric light will (at first, at any rate) be situated at relatively considerable distances apart, and consequently undertakers will have to use long stretches of conductors in order to reach such consumers; and this they can only afford to do by the use of overhead conductors. We are of opinion, therefore, that unless new discoveries should enormously reduce the cost of the work, to an extent which at present we see no reason to anticipate, it will be a practical impossibility to introduce electric lighting in country districts except by means of overhead conductors; therefore, the adoption of a fixed rule that all conductors must be carried underground, would mean an absolute prohibition of electric lighting in such districts.

"Another and almost equally important question arises out of the use of electricity for motive purposes. We are of opinion, that for the purposes of electric traction in rural districts, overhead conductors will be found to be the only mode on which long lines can be made commercially successful, and that a fixed rule, which forbade their use throughout the United Kingdom would seriously retard the development of electrical motive power.

"In view of these circumstances we respectfully urge that your Department should not lay down as a settled principle that no overhead conductors should be allowed; but that, in the rural districts at least, the circumstances of each particular case should be allowed to determine whether overhead work should or should not be sanctioned.

"In conclusion, we beg leave to say, that while we concur in the view that the use of overhead conductors should be regulated as stringently as the public interests may require, we think that the electrical engineering industry should not be hampered by their being unconditionally forbidden; and we submit that wherever in small provincial towns or rural districts the undertakers are able to satisfy your Department that underground work would mean prohibitive expense, or for any other reasons would be impracticable, and that the objections to overhead conductors would be so slight that they might be disregarded, sanction should be given to the erection of overhead conductors, subject to such regulations and restrictions as experience may show to be necessary.

"December, 1891."

THE ECONOMIC LIMIT OF LARGE-POWER UNITS.*

BY "CARLETON."

This subject has always been one of deep interest to all persons interested in electrical development, and many electrical engineers have in no way changed their views from the first concerning the size and style of engine for electrical requirements. The vital question to be considered by electrical promoters is not what a steam horse-power costs at its station, obtained from an improved and complicated engine designed to show at its official trial a unit, for a pound, and a fraction of a pound, of coal; but what does it cost to produce light commercially at the permanent location of the lamp.

Take, for example, the long-stroke, slow-speed, direct-acting, compound or triple-expansion engine, with its multiplicity of valves and intricate connections. Floor area in places where real estate is of great value becomes the first consideration. Then multiplicity of parts increases the liability of disaster, while variation of load produces internal condensation of steam in the cylinders, caused by constantly changing temperatures, resulting in direct loss, showing a consumption of coal per horse-power per hour in the majority of direct-acting engines to be over 5lb.

Electric railway work is proving to be the most severe problem the steam-engine builder ever contended with. Rolling and saw mills were thought to be very exacting in their requirements; but now the yielding of steel and iron billets in their semi-fluid state when entering a train of rolls, as well as the entering of the circular or band saw into the log, passes out of mind when the engine-builder knows and realises that many times during the day the majority of street cars on an electrical railway start and stop simultaneously. These conditions produce a blow on the piston of the engine, which is communicated to the cross-head pin, crank pin, main bearing, and then to the dynamo through the belt. As long-stroke slow-speed engines, with an independent cut-off for the valves, run with but little if any compression in the cylinders, there is nothing to relieve this sudden blow which occurs twice during each revolution, and the result is quickly seen in the bearings of reciprocating parts, as well as the disintegration and unreliability of belts. The lining

* From the *Electrical Engineer* of New York. (Abstract.)

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metal of the various boxes, which is comparatively soft, yields to the violent and sudden stress put upon it, necessitating frequent driving of keys and adjustment of quarter boxes, accompanied by heat from excessive friction, not only resulting in loss of power, but in increasing the cause of expense and chances of disaster.

It is to be regretted that numerous electrical engineers are for the sake of personal advancement constantly bringing forward, at the expense of the shareholder, new and untried experiments in special engines. The compound non-condensing engine has had quite a run, much to the disgust of the shareholder, who finds with variable load and pressure the direct-acting non-condensing engine is more economical. As the electrical engineer is without financial responsibilities, the burden of loss is not with him. It is well known that the Corliss Steam-Engine Co., and the Armington and Sims Engine Co., Providence, R. I., builders of long-stroke, slow-speed, and short-stroke high-speed engines, respectively, refused to build non-condensing compound engines. Comment is unnecessary, unless it be to say that these well-known builders are more friendly to the electrical shareholder than his electrical adviser.

The various triple-expansion engines which are now attracting considerable attention have not yet been long enough in operation to judge of their fitness for central-station work. They possess many of the objections before mentioned, and their greatest claim for superiority is based on their economical running. The measure of economy of the steam-engine is determined on the consumption of steam per horse-power per hour. The builder cannot always guarantee the amount of coal to be used in developing a certain amount of horse-power, as more boilers evaporate seven pounds than nine pounds of water to a pound of coal, while some of the builders of safety water-tube boilers claim an evaporation of ten and even eleven pounds of water to a pound of coal.

If the required favourable conditions can be given to the properly proportioned and constructed triple-expansion engine, viz., constant pressure, load and speed, then its economical performance cannot be surpassed; but vary the conditions, as in electrical railway work, and the results must be anticipated by the practical manager, without mechanical knowledge. Many of the modern fast ocean steamships claim to produce a horse-power with their triple-expansion engines for from 1½ to 1⅞ pounds of coal; but as a round trip of these steamers costs $75,000, and the consumption of coal is 300 tons per day, it is, of course, impossible to obtain reliable data, and the result given is arrived at by estimating. From the Navy Department *Intelligence Series* we find it is customary to estimate the amount of coal consumed on the new cruisers. How can it be otherwise, as facilities for weighing cannot be had? There is, however, the published result of one steamship trial worth repeating. The builders claimed a horse-power for their engines of one and one-half pounds of coal. Permission was asked by a professor of a technical college to ascertain if possible the truth of the statement. It was freely given, possibly because it was thought impossible. The ship and engines were reported to be in first-class order and condition. The professor and about twenty assistants carried on their experiments, and after a continuous run of eighteen hours, actual results showed a horse-power for two and one-fourth pounds of coal. A claim was then made that the ship and engines were not at their best, but would soon be made so, and an invitation to repeat the experiments was given and accepted. Nearly three years have passed since the first trial, yet the professor has never been asked to continue his investigations, and he never will be although he obtained and gave as reliable data commercial results. They were not wanted. In case of warm bearings, or breakings of parts of the steamship engines, it is an easy matter to slow down, and if necessary to stop for an hour or two, but not so with the triple-expansion street railway engine, with more than double the number of valve-gear parts. *It must not stop.*

Electrical engineers from abroad say we are three years behind them in electrical development, and claim that our large unit system of engines, with belt transmission, is also three years behind modern progress, although these large engines in some parts of the country have not yet started. Let us hope for their success.

To say that the high-speed high-pressure engine meets all requirements would be absurd, yet it must not be denied that this class of engine has made rapid advancement when it is known that the builders of the first successful high-speed engine in this country were compelled about ten years ago to lay aside for two years their inventions and improvements, owing to intense and not well-founded opposition. It is this class of engine that has more than contributed to doubling the horse-power of the world, at the same time compelling the builders of every known kind of engine to run it faster, and improve its design and workmanship. It has compelled boiler-makers to use better materials and improve their workmanship, as higher pressures are demanded. It has not only been the means of improving the standing of mechanics, materials and engineers, but it was the pioneer engine that gave commercial electricity its first start, enabling it to get a foothold.

The credit of bringing the high-speed engine into electrical prominence, although a matter of necessity, belongs to Mr. Thomas A. Edison. Seven of the "Jumbo" combinations are still running in a central station in Milan, Italy, and although antiquated, give proof of the wisdom of the first thoughts of Mr. Edison, that should have been enlarged on by his less able and erratic followers and assistants. Another pleasing and successful illustration is the Thomson-Houston multipolar dynamo directly connected to the double upright high-speed engine for ship lighting on the Government cruisers and merchant steamers. A large number have been built, and the combination grows in favour on its merits.

Why not continue and proceed on this line of advancement, arriving at the extreme power unit of the future for large central and piston speed of 600 or 750ft.? Stroke should be 18 or 20in., stations, which is to be a compound condensing engine of 500 H.P., with a speed of not less than 200 revolutions per minute, which will permit of direct-acting, positive valves, without complication. Armatures should be part of the engine shaft, of as great a diameter as practicable to compensate for the absence of driving pulleys or balance wheel, a most essential requisite. Simplicity reduces to a minimum the liability of disaster.

Two of these extreme units would not be suitable for a station of 1,000 H.P., as a number of these combinations of various powers should be placed in each station, and if water for condensers cannot easily be obtained at small expense, then use the direct-acting engine, as about 25 times the amount of water pumped into the boilers for a certain load is required for the condensers. As the engine and dynamo duty increases, add to the present requirements another unit, and when decreasing, take from it permanently, at the same time stopping all expense of that particular unit without destroying its efficiency as a reserve factor.

The managers of small stations should not be carried away with the one gas-holder theory, but build wisely and well for their patrons and shareholders.

LEGAL INTELLIGENCE.

Anglo-American Brush Electric Light Corporation v. King, Brown and Co.

In the House of Lords on Thursday last week, the case of the Anglo-American Brush Electric Light Corporation (Limited) v. King, Brown and Company came before the Lord Chancellor, Lord Herschell, Lord Watson, Lord Macnaghten, and Lord Field, in the form of an appeal from the judgments of the Lord Ordinary and the First Division of the Court of Session, Edinburgh, revoking the appellants' letters patent.

The Attorney-General, Mr. Moulton, Q.C., and Mr. J. C. Graham appeared for the appellants; while the Solicitor-General for Scotland and Mr. Daniell represented the respondents.

The ATTORNEY-GENERAL, on behalf of the appellants, said this was an appeal from the First Division of the Inner House, Edinburgh, affirming the judgment of Lord Trayner, whereby he ordered the appellants' letters patent to be revoked. The case originally came before the Scotch Court in the form of an action by the respondents, Messrs. King, Brown and Co., carrying on business at Rosebank Works, Broughton-road, Edinburgh, against the appellants, to revoke the letters patent on the ground, amongst others, of want of novelty. The letters patent in question were granted in 1878 to Mr. Herbert John Haddan, for certain "improvements in apparatus for the generation and application of electricity for lighting, plating, and other purposes." The invention was a communication from abroad by Mr. Charles Brush, of Cleveland, Ohio, in the United States of America. The letters patent were now vested in the appellants, and were known as Brush's letters patent. The invention related to improvements in dynamo-electric machines. The third claim of the patent related to the commutator. Lord Trayner was of opinion that, though as a mechanical arrangement it was new and useful, and not open to challenge, yet that, inasmuch as it was not foreshadowed in the provisional specification, the letters patent were invalid. The fourth division of the description of the invention related to the maintenance in dynamo-electric machines of a "magnetic field." This part of the invention was commonly known as "compound winding," and was generally referred to as such in the evidence. The Attorney-General then proceeded to explain to the Court the meaning and respective advantages of series, shunt, and compound-winding. Lord Trayner and the other Judges of the Inner House decided that the claim for the latter was invalid, by reason that compound-winding had been published, firstly, by the publication of a specification filed by Mr. Samuel Alfred Varley, in pursuance of letters patent granted to him in 1876; and secondly, by the use and exhibition at Messrs. Siebe and Gorman's Works in London, in or about the year 1877, of a machine invented by Mr. S. A. Varley. With regard to the portions of Mr. Varley's specification which were relied upon by the respondents as a prior description of "compound-winding," he (the Attorney-General) submitted that this description was not a description of "compound-winding," as described and claimed by Mr. Brush, and would not have been understood as such prior to the date of Mr. Brush's patent, and that it was vague and misleading, and not sufficient to instruct the public how to perform the invention to which it was by the respondents alleged to relate. The other anticipation of Haddan's claim for compound-winding was the machine used at Messrs. Siebe and Gorman's Works in London. Mr. Gorman's evidence

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and that of his foreman, Mr. Myers, was to the effect that a machine was made somewhere about the beginning of 1878; that it was tried on several occasions, on each of which alterations had to be made on it; that subsequently it was laid aside in a place in the works used for storing brass, where it was left unnoticed and untouched until about a year prior to the trial of the action. He (the learned counsel) maintained that as to this machine it was not proved to have been used as a compound-wound machine; that the user of the machine, such as it was, was not a user in public, and that the machine was an experimental one; and the experiments having failed, it was laid away and treated as an abandoned experiment, and that it was, therefore, not such a prior user as would render the claim invalid for want of novelty. He submitted that the judgments appealed from were erroneous and contrary to law, and ought to be reversed on the grounds that the letters patent were always, and now were, valid in all respects; that the specification of Mr. S. A. Varley of 1870 did not contain a description of compound winding, and did not anticipate the invention claimed by Brush in the letters patent in question; that the machine made at Siebe and Gorman's works was an abandoned experiment, and not a compound-wound machine, and was not published, and was not a publication of compound winding as claimed in Brush's specification; that the commutator claimed and described in Brush's specification was duly and sufficiently foreshadowed and comprised in the provisional specification, within the meaning of the law relating to letters patent; and that none of the objections to the validity of the letters patent relied on by the respondents were proved or capable of proof.

The hearing of the case was adjourned.

FRIDAY, DECEMBER 4TH.

The ATTORNEY-GENERAL, in continuing his arguments in support of the appeal, said the respondents alleged that "series-shunt" or "compound-winding" was described in the patent specification, No. 4,905 of 1876, by Mr. Samuel A. Varley, in terms sufficiently clear to enable the ordinary skilled workman to make it, that a dynamo-electric machine containing the series shunt-winding had been manufactured under the directions of Mr. Varley prior to the date of the alleged letters patent, and that the machine had been publicly used for the production of electric light for the business purposes of Messrs. Siebe and Gorman, submarine engineers, London, in 1877. He contended that the machine at the works of Messrs. Siebe and Gorman was an abandoned experiment, and not a publication of compound-winding as claimed in Mr. Brush's specification, and that Mr. Varley's specification, No. 4,905 of 1876, added nothing to the then existing stock of public knowledge. The learned counsel had not concluded his arguments when the Court adjourned till Monday.

MONDAY, DECEMBER 7TH.

The ATTORNEY-GENERAL, in resuming his arguments in support of the appeal, again dealt with the point as to the publication of the machine made at the works of Siebe and Gorman, and used in 1877 to enable a photograph to be taken of an ice-making machine. He submitted that after experiments were made with it it was put aside and abandoned, and that there was never any publication.

Lord WATSON said the persons who saw it knew only that it was a machine used to produce electric light.

The ATTORNEY-GENERAL remarked that that was so. He went further, and said that whatever happened the inventor himself abandoned the machine.

The LORD CHANCELLOR said it was possible that the inventor would not have thought of it again but for the fact that the incandescent lamp was invented a year or two afterwards.

The ATTORNEY-GENERAL, in conclusion, submitted that the Brush patent was valid on the ground that there was no sufficient description of a shunt-series machine in Mr. Varley's patent, and that Mr. Brush's disclosure was the first made on the subject.

Mr. MOULTON, in following on the same side, said the proper mode of deciding this question was to ascertain what was the precise invention in question, and whether it was or was not fully disclosed in Mr. Varley's patent. He desired to direct their Lordships' careful attention to the first question, namely, which was the precise invention. There had been many approaches up to the complete perfect invention. His case was that Mr. Varley did not disclose anything new. He simply described the first and second steps to be taken in arriving at the perfect invention, but he said nothing about the third and final step; therefore, he added nothing to what was the admitted stock of knowledge at that date. The third step which produced compound winding was not in any way disclosed by Mr. Varley's specification. Series winding was known, and self-excitation was known; and Mr. Varley's specification brought before the mind of persons reading it that the mode of constructing the machine was to have two external circuits, both of them going round the magnets, but coming from separate bobbins of the machine.

The LORD CHANCELLOR: Separate sources of electricity.

Mr. MOULTON: Yes. That method, however, did not give the compensation which was the real value of compound winding. In the case of the shunt there was only one wire round the magnet, and there was only one external circuit. The exact invention that Mr. Brush made was to allow the two circuits going round the magnets to have a common part—not to be complete circuits, but to have the power of interfering with one another. That was the third step which was taken by Mr. Brush, and not by Mr. Varley. He submitted that the words used by Mr. Varley in his specification described a then existing arrangement which was not compound winding, and to which something must be added to make it compound winding.

Mr. MOULTON, continuing, said Mr. Brush seemed to have made his machines in America before the date of his patent. With the shunt series one could not fail to get compensation. Mr. Brush had put into the hands of his opponents a method by which they could obtain compensation, and, therefore, he was entitled to the merit of that compensation. As to the alleged prior publication, he submitted that there was not a sufficient user of the machine made at Messrs. Siebe and Gorman's works to acquaint the public of the invention.

The LORD CHANCELLOR: But when it was used do you say it was not used as a series-shunt winding machine?

Mr. MOULTON: Not at all times.

At the conclusion of the learned counsel's arguments their Lordships intimated that they would consider whether it was necessary for them to hear the Solicitor-General for Scotland on behalf of the respondents.

John Denby v. Ernest Scott and Mountain.

Judgment was pronounced in the Court of Session on Wednesday by Lord Kyllachy in the action by John Denby, stereotyper and electrotyper, 4, Swinton-row, Edinburgh, against Ernest Scott and Mountain (Limited), engineers, Close Works, Newcastle-upon-Tyne, for £500 damages for alleged breach of contract. The pursuer stated that up till the end of the year 1890, or the beginning of 1891, the defenders' business was carried on under the name of Ernest Scott and Co., and thereafter under the name of Ernest Scott and Mountain. Ernest Scott and Co. had exhibits of their electrical manufactures, and in particular of dynamo machines, at the Edinburgh Exhibition of 1890. In June of that year the pursuer purchased a dynamo for the specified and particular purpose of being used in his business as an electrotyper. It was delivered about the middle of September, and was properly fitted up; but pursuer averred that it turned out unfit for the particular purpose for which it was furnished, in respect that—(1) it was constructed both for the purpose of nickel-plating and electrotyping—a dynamo constructed for nickel-plating not being suited for electrotyping; (2) the dynamo was much too powerful for electrotyping, and caused the deposit of copper to take a granular form instead of presenting a smooth, tough surface; and (3) it could not produce an electrotype sooner than 12 or 14 hours, whereas it should produce one within from three to five hours according to the quantity of moulds in the bath. The purchase price of the machine was £55, and the pursuer stated that through its breakdown he was unable to execute a large order, and that his business suffered in other respects on account of the bad work it produced. The defenders denied that they entered into any contract with the pursuer. They explained that at the end of December, 1890, they purchased the business carried on at Close Works by Ernest Scott and Co., and were now carrying on the same. The machine, they said, was not supplied by their predecessors for any particular purpose, nor did the defenders assume any responsibility or liability in respect of any contract entered into with the pursuer. The defects in the dynamo were said to have been due to insufficient fitting up, lack of knowledge on the part of the pursuer, want of skill in manipulation, and to the absence of necessary instruments.

At the proof, which was led some time ago Mr. Ure, Mr. McLennan and Mr. Daniell, instructed by Mr. Thomas Liddle, S.S.C., represented the pursuer; while Mr. Asher, Q.C., and Mr. Watt, instructed by Mr. David Hunter, S.S.C., represented the defenders.

Lord KYLLACHY, holding that the pursuer had failed to prove his case, assoilzied the defenders, and awarded them expenses.

In giving judgment, his LORDSHIP said he did not feel altogether sure about the decision in this case. Long as the proof had been, it had not quite cleared up the mystery which he thought still surrounded the history of this dynamo. His Lordship had, however, after carefully reading the correspondence and the evidence, come to the conclusion that he must find for the defenders, on the ground that the pursuer had not proved that the dynamo in question was disconform to contract. He did not propose to state his views on the evidence in detail, but he might give some of the points on which he had formed his opinion. In the first place, his Lordship was disposed to accept the pursuer's reading of the contract, viz., that the defenders undertook not merely to supply a dynamo answering the description of No. 5, class 6, but they also guaranteed that the machine furnished was suitable for electrotyping, and would, under proper conditions, and worked by the pursuer's gas engine, particulars of which were given, produce a satisfactory deposit of copper. He did not think, indeed, that this was seriously disputed by the defendants. At any rate, his Lordship had little doubt that their undertaking went thus far. In the second place, he thought it was equally clear that the dynamo which the pursuer furnished did not, when supplied to the pursuer's works and tried practically over a period of some months, give satisfactory results. On the contrary, it was, his Lordship thought, clear that the results were hopelessly bad; and that the pursuer, after trying everything he knew, and everything the defenders suggested, was unable to effect any improvement, the result being that his business, if not destroyed, was greatly injured, and he suffered in various ways serious loss and damage. Now as to the cause or causes of this failure. The direct and positive evidence was not at all satisfactory. He could not say that the defenders had succeeded in establishing any definite fault as against the pursuer's bath, or the solution, or his manipulation of his bath. So far as appeared, the pursuer worked throughout in the same manner as he had successfully worked his battery; and experienced electrotypers, such as Mr. Clyde, whom he called in, found nothing wrong with his methods; and the defenders, in their correspondence, suggested nothing wrong. Their complaint was that the pursuer expected quicker work with the dynamo than with the battery, an expectation which, according to Mr. Fairfoul was entirely right. Mr. Low said he suggested that the pursuer had too weak a solution, but he did not mention this in his correspondence with his principals, and nobody suggested the main complaint, the granulated character of the

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deposit. It was true, also, that one of the defenders'witnesses, Mr. Fairfoul, condemned the use of acid in the solution when a dynamo was being used, and the whole difficulty might have been due to that cause; but all the other witnesses approved of the use of acid, although some of them appeared to hold that with a dynamo less acid should be used than with a battery. Altogether his Lordship was bound to say that the defenders, if the onus rested on them, had not, in his opinion, succeeded in explaining the admitted failure of the results by anything to which they could point connected with the pursuer's bath or of his methods of manipulation. It remained, however, to consider whether the pursuer, on whom the onus primarily lay, had been able to prove affirmatively that there was something wrong with the defenders' dynamo. It was not enough for the defenders to say that there was no proof of anything wrong with the bath. The fault might have been there, although no particular fault could be proved. The pursuer must, in order to succeed, show that there was something wrong with the dynamo. Now, his Lordship was bound to say that, apart from the proved results of the recent trials of the machine in Mr. Goskirk's and Messrs. Chambers' works, he should have been, on the whole, inclined to hold that the balance of the evidence was against the suitableness of this dynamo for purposes of electrotyping. He meant that, apart from the trials referred to, he should have been inclined to conclude that this dynamo was of too high a voltage, or electromotive force, for electrotyping, and that for some reason it did not admit of having its voltage reduced by the usual expedients, or reduced so as to give a good result. But, then, these recent trials, if they were to be trusted, appeared to demonstrate that the voltage was not too high, but quite suitable; and that this identical dynamo, worked in connection with ordinary baths, and under ordinary conditions, had repeatedly produced electrotypes to which no fault could be found, and which, indeed, were admitted to be of exceptional excellence. The evidence of Mr. Fairfoul, Mr. Mackay, and Mr. Goskirk all seemed to establish that beyond doubt. Unless, therefore, there was some reason to believe that the dynamo, as it now stood, had been in some way altered, and was not now in the same condition as it was when it left the pursuer's works, his Lordship had not been able to see any escape from the conclusion that, whatever might have been wrong with the pursuer's results, the fault was not in the dynamo; and, that being so, the question was brought to this—was he to believe or disbelieve the defenders' evidence on this subject? His Lordship confessed, when it was so put, that he hesitated to come to the conclusion that—contrary to the testimony of Mr. Mountain, concurred in by Mr. Rolfe, and not impugned or contradicted by any direct evidence to the contrary—the defenders were guilty for the purpose of defeating the pursuer's claim of a gross and deliberate fraud; that was to say, that they altered previous to the trials in Edinburgh the armature or other parts of the machine. It was no doubt unfortunate that the machine having been returned to the defenders' works, he thought in April, remained at these works in Newcastle until September, when it was again sent down to Edinburgh to be tried at Mr. Goskirk's works; but his Lordship could not say that that was in his opinion sufficient, as the pursuer suggested, to deprive the recent trials in Edinburgh of all value. His Lordship thought, difficult as the whole case was, that it was on the whole more probable that there was something wrong with the pursuer's management of his bath or management of his gas-engine, than that the dynamo, which worked so well now, was a different machine from that supplied to and worked by the pursuer. On the whole, therefore, he had come to the conclusion that the pursuer had failed to prove his case, and that the defenders must be assoilzied with expenses.

International Cable Company (Limited) v. Suren, Hartmann and Co., and W. T. Henley's Telegraph Works Company (Limited).

In the Chancery Division on Tuesday, Mr. Justice Mathew had before him the case of the International Cable Company (Limited) v. Suren, Hartmann and Co. and W. T. Henley's Telegraph Works Company (Limited) (third parties, which was an action brought by the International Cable Company to recover £250 and £1,000 payable in respect of shares which had been applied for and allotted in the plaintiff Company. The Company was incorporated in 1886. Application was made by Messrs. Suren, Hartmann and Co. in the usual form, the issue being made upon a prospectus which mentioned the capital to be £1,000,000 in 100,000 shares of £10 each. Upon the first issue 10s. was payable on application, 10s. on allotment, and £2 at the expiration of one month from allotment. The 10s. on application was paid, and the £250 due on allotment had been paid since the action, so that the claim related now solely to the £1,000 in respect of the £2 call. The issue was between Messrs. Suren, Hartmann and Co. and Messrs. W. T. Henley's Telegraph Works Company (Limited), who were brought before the Court upon a third party notice. Messrs. Suren, Hartmann and Co. claimed to have been indemnified by Messrs. Henley's Telegraph Works Company under the terms of an agreement which had reference to an anticipated order for the manufacture and laying cables between Lisbon to the Azores, and thence on to the American coast. The International Cable Company (Limited) is in liquidation, and the list of contributories was stated to have been settled by certificate of the Chief Clerk.

Mr. Graham Hastings, Q.C., and Mr. Grosvenor Woods appeared for the plaintiff company; Mr. Phipson Beale, Q.C., and Mr. J. W. Baines for the defendants; and Mr. W. F. Robinson, Q.C., and Mr. Row for the Henley's Telegraph Works Company.

His LORDSHIP, at the conclusion of the arguments of the learned counsel, held that the defendants were entitled to be indemnified by Messrs. Henley's Telegraph Works Company, at whose request the shares had been applied for, and entered judgment for the plaintiff company for £1,000 and costs.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November* 27, 1891.

The Berliner Microphone Patent.—The recent telephone patent is still the topic of the hour. The patent records are at present inaccessible, as so many certified copies of the proceedings in this case have been ordered that documents are steadily in the hands of copyists. The Berliner patent has made all the greater sensation as there has been a widely spread, though erroneous opinion, that telephone apparatus would become practically free after the expiration of Bell's original patent dated 7th March, 1876. The establishment of the microphone claims has been a rude awakening to those who had hoped for any such termination of the telephone monopoly. There will undoubtedly be vigorous competition set on foot by 1894, when the second Bell patent runs out; indeed, there are rumours even now of organizations preparing to go into the telephone business at the earliest opportunity; but to all these the Berliner claim, whether substantiated or not, will be somewhat of an inconvenience, although it is generally admitted that it will be very difficult to hold the patent against the attacks that will be made on it.

A 125 H.P. Thomson-Houston Electric Locomotive.—The Thomson-Houston Electric Company has recently been building an electric locomotive of capacity sufficient for handling freight cars; it will be formally exhibited to an invited delegation of electricians to-morrow, but some details regarding the apparatus have already leaked out. The machine is to be used at Whitingsville, Mass., and is to be employed for the purpose of handling freight cars between the works of the Whiting Machine Company and the railroad, about two miles distant. The locomotive complete weighs about 21 tons, and is driven by a single motor of about 125 H.P. capacity, the wheel base is six feet four inches, and the motor drives directly a single pair of wheels three feet six inches in diameter; these are connected to the other pair by the connecting rods. The normal axle speed will be about 40 revolutions per minute, while the armature will make nearly 1,000. The speed reduction is accomplished by spur gearing running in oil. In the cab of the locomotive is placed the controlling mechanism with the other accessories necessary, the power to be supplied by an overhead wire, from which current will be taken by the trolleys as usual.

The Electric Railway Business.—The electric railway business in general is a little sluggish just now, owing to the lateness of the season, but construction is kept up all winter, and the principal companies are still busy turning out machines. These are now nearly all single-reduction with a few gearless, and a few of the old type for use on already established roads who are opposed to innovation. Single-reduction machines, however, have now acquired so good a reputation that they are usually ordered for regular equipments. Railway managers still look askance at gearless machines, and indeed it is quite possible that they may continue to do so if the single-reduction gear motors give as thorough satisfaction as they seem to be doing at present.

CORRESPONDENCE.

PLATINOID *v.* COPPER FOR D'ARSONVAL GALVANOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 4th inst. Mr. C. W. S. Crawley refers to the question of whether d'Arsonval galvanometers should be wound with platinoid or copper, which had been raised by Prof. Ayrton in the discussion on Captain Sankey's Paper.

Although copper has important advantages where the instrument is only required to measure the *current* passing through it, its large temperature coefficient is a serious objection in cases where a *potential difference* is to be deter-

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mined from the deflection of the galvanometer. The latter condition was the one under which Captain Sankey's instruments were used, and here platinoid might have been employed with advantage.

In the case of the 500-ohm instrument chosen by Mr. Crawley as an example, the difference of $\frac{1}{80}$th per cent. in the temperature coefficient may not seem large; but to estimate it at its true value it should be remembered that the temperature coefficient of the all-platinoid instrument is only about $\frac{1}{30}$th per cent., whilst that of the copper-platinoid combination is $\frac{1}{28}$th per cent. The temperature coefficient is therefore nearly double that of the simple platinoid galvanometer. Now, the disadvantage of nearly doubling a temperature coefficient is too well known to need further comment; in fact, it is a difference of the same order as that between platinoid and German silver.

But Mr. Crawley in his comparison has entirely neglected the resistance of the suspension of this coil, and, as this suspension is constructed of platinoid wire by well-known instrument makers, this resistance alone amounts to 10 ohms. Now this omission would lead to totally wrong conclusions if we were comparing the relative advantages of platinoid and copper-wound d'Arsonval galvanometers of somewhat low resistance, and, indeed, even in the case he refers to, the real sensibilities for P.D. are not in the proportion of 1 to 25, as stated by him, but as 20 + 10 to 500 + 10, that is as 1 to 17.

If, however, the current to be measured be such that 10 ohms be the right resistance to give to the coil when wound with platinoid, then if wound with the same number of turns of copper wire of the same gauge its resistance will be 0·4 ohm. Hence, since the total resistance between the galvanometer terminals, including the suspension, will be 10·4 ohms for the copper-wound coil and 20 ohms for the platinoid, the copper-wound instrument will not be even twice as sensitive as the platinoid one, and will have nearly twice the temperature coefficient.

For low-resistance d'Arsonval galvanometers it would be, be, however, a mistake to employ the same number of turns of wire of the same gauge, whether the wire were of copper or of platinoid. In fact, since there is this fixed resistance of about 10 ohms in the suspension itself, the coil should have 10 ohms resistance, so as to obtain maximum sensibility for potential difference measurement, whether wound with copper or platinoid. And if each coil have the same resistance there will be something like four times as many windings in the copper coil as in the platinoid. Hence, both for potential difference and for current measurement such a copper-wound instrument will be about four times as sensitive as the platinoid one, but it will have nearly 10 times as large a temperature coefficient.

The choice in this case, therefore, lies between a copper-wound instrument with sensibility 4, and a temperature coefficient $\frac{1}{5}$ per cent., and a platinoid-wound instrument with a sensibility 1, and a temperature coefficient $\frac{1}{30}$ per cent.

If sensibility for small potential difference is all important then the former is the better; whereas if constancy of sensibility for potential difference measurement at various temperatures is the chief desideratum, then the platinoid-wound instrument is undoubtedly superior.

But probably the best way of showing the superiority generally of platinoid-wound d'Arsonval galvanometers for potential difference measurements is by giving the following concrete example:—Let no alteration whatever be made in the platinoid sheet used at Thames Ditton to carry the main current, but let the 430-ohm copper coil of the d'Arsonval galvanometer used to measure the potential difference at the terminals of this sheet be replaced by a 10-ohm platinoid coil, the price of which would, of course, be less; then the deflection for a given current passing through the sheet will be increased 25 per cent., and the temperature coefficient reduced to $\frac{1}{18}$th of its value for the copper coil.

As I have already trespassed so much on your valuable space I will not go into further details, and the subject is fully dealt with in a forthcoming work on "Galvanometers" by the present writer.—I am, &c.,

T. Mather.

Central Institution, Exhibition-road.

THE THEORY OF THE WIMSHURST MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: As M. Pellissier appears to me to have raised several new points in his last letter, I should be glad if you will permit me to say a few words in reply; after which I shall be satisfied to leave it to you and your readers to decide on the merits of the controversy, and thereby remove M. Pellissier's apprehension that it may trench on the boundaries of eternity.

Arguing from the quotation from Prof. Thompson's theory we are, according to M. Pellissier, left to choose one of two alternatives, namely, that Prof. Thompson either (i.) starts with the symmetrical distribution on one plate which I have assumed, or (ii.) assumes that the positive electrification of B_5 is produced by the influence of A_1. M. Pellissier maintains that the second alternative is an impossible one, because the neutralizing rod is to earth at the middle. But I think he forgets that there is usually no metallic connection between the middle of the neutralizing rod and the earth, but a support of well-seasoned wood. This is a sufficiently good insulator to produce a discharge of positive electricity on the carrier B_5. This, I think, with all deference to M. Pellissier's different interpretation, is Prof. Thompson's view; for he says, "As each carrier comes up to be touched by the neutralizing brush there will be a rush of electricity *between the two ends of that diagonal conductor*, where similar actions, but of opposite sign, are taking place."

M. Pellissier's theory of lateral action would thus be unnecessary to explain the creation of a charge on the second half of each plate. It also appears to me, after reading his amended exposition of his theory in *La Lumière Electrique*, October 10th, that the theory of lateral action is insufficient; and for the following reason. When a carrier in contact with a brush receives, say, a negative charge by the lateral action of a positive carrier that follows, it will tend to prevent this follower when in contact with the brush from receiving an equal negative charge. The result will be that by lateral action the effect of the second half of the plate will be nearly equivalent to what it would be if half its carriers were removed. This, we know, except with machines having an unnecessarily large number of carriers, would prevent increase of the charge.

In his article in *La Lumière Electrique* and in his last letter M. Pellissier abandons the attempt to explain the auto-excitation of the Wimshurst machine, and contents himself with explaining the process by which the machine is excited by the application of an external electrified body. His reason for considering this a sufficient theory is:—"Auto-excitation is not an essential part of the action of the machine, since the machine requires in certain cases to be excited." Since these machines are always made self-exciting, surely this is a *non sequitur*.

Finally, I was surprised to note that M. Pellissier claims to be the originator of the theory of the growth of the charges on which part of the theory this discussion at least has shown that he and I are in perfect agreement. I was surprised to note this, because it is the theory which I have always held on this question, and is identical with the theory which I venture to say anyone, on full consideration of all the circumstances, will find given in my book. M. Pellissier has put a different interpretation on my explanation of this theory; but the words he underlines do not necessarily mean that "fresh charges are added to the old ones as in the ordinary multipliers." Even on the true theory of growth, claimed by M. Pellissier, and expounded with the lucidity characteristic of his countrymen, I maintain that it is correct to say that, *owing to the motion of this latter disc, the charges originally upon it will be increased by its action*; for throughout my explanation I have considered the charges on the two halves of the discs as stationary in space while the discs with their carriers were rotating, and therefore not as charges attached to any particular carrier. This method I think very much simplifies the theory; and these stationary, positive, and negative charges on opposite sides of the neutralizing rods *do* increase, owing to the motion of the discs according to the compound interest law as I have stated in the next sentence.—I am, &c.,

J. Gray.

December 5.

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TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

TENDERS INVITED.—The Aston Manor Local Board invite tenders for the complete electric light installation of the public baths. Further particulars may be obtained from Mr. W. A. Davies, A.M.I.C.E., engineer to the Board, Public Offices, Aston Manor, and tenders are to be sent to the Chairman of the Baths Committee by the 21st inst.

CHRISTIANIA (NORWAY).—We announced in our last issue that Messrs. Schuckert and Co. had obtained the contract for lighting the town of Christiania. The central station, which is intended to work at the commencement with 1,200 minimum to 1,600 maximum horse-power, and with a large plant of accumulators, is to be completed by the autumn of 1892, and is to cost, including buildings, &c., about £60,000.

CRYSTAL PALACE EXHIBITION.—We learn that one of the attractions at the forthcoming Electrical Exhibition at the Crystal Palace will be a telephone-room fitted by the National Telephone Company, in which music from the provincial and metropolitan theatres will be heard by telephone. The National Company will also establish inter-communication in the Palace between the various stalls, and their own exhibit will form an interesting feature of the Exhibition. Arrangements are being made for establishing communication between the Exhibition at the Palace and the metropolitan exchanges.

THE ST. PETERSBURG ELECTRICAL EXHIBITION.—The *St. Petersburg News* states that the number of French exhibitors at the St. Petersburg Exhibition increases every day, and it is even now possible to predict a very full exhibit from French manufacturers of electrical plant and apparatus. The French electrical engineers are, continues the journal, exhibiting many novel electrical inventions and improvements which up till now the Russian public were unacquainted with. No mention is made of any prominent British exhibit.

MESSRS. EWART AND SON.—This firm have recently added to their old-established business at Euston-road, N.W., an electrical engineering department, and notify us that they have several important contracts on hand. Messrs. Ewart and Son also supply electrical fittings and contract for house wiring, &c.

THE SMITHFIELD CLUB CATTLE SHOW.—The ninety-fourth annual show of this Club is being held this week, and closes to-day (Friday). The usual exhibits of engines, &c., were on view, but little or nothing of electrical interest was to be seen. Messrs. Crossley Bros. (Limited) had on view one of their B type of electric light engines, fitted with all the latest improvements. Mr. E. S. Hindley showed a number of his well-known portable and semi-fixed engines. The Priestman oil engine and the Trent gas engine occupy the usual prominent positions; but as one of the rules of the Smithfield Club prohibit the exhibition of working machinery, little interest was taken in the exhibits. Messrs. Robey and Co., Messrs. Ransomes, Sims and Jefferies, Messrs. Marshall, Sons and Co., Messrs. Francis Morton and Co., and Messrs. W. H. Willcox and Co. each had on view some fine examples of their special manufactures.

ELECTRICAL SIGNS.—Messrs. G. Shearod and Co., of 2, Praed-street, W., notify us that they are prepared to submit sketches and designs for stands, signs, show-cards, &c., and for the fixing of same, for the Crystal Palace Exhibition. This firm were entrusted by the Canadian Commission of the Colonial and Indian Exhibition with the sign work required for their extensive exhibit.

MESSRS. J. K. FAHIE AND SON.—This firm notify us that they are installing the electric light at the residence of Mr. J. J. Murphy, the well-known Irish brewer. The installation is for 100 incandescent lamps. The plant consists of a Robey engine and a 6-unit Elwell-Parker dynamo. Accumulators will also be used.

MESSRS. RALPH HEATON AND SONS, THE MINT, BIRMINGHAM.—This firm inform us that they have appointed Messrs. Edward Le Bass and Co., of 49, Lime-street, E.C., as agents for their London home and export trades. They call special attention to their seamless copper tubes, manufactured under a new process, and a special high conductivity copper wire for electric light and telephone work.

MESSRS. BAGSHAWE BROTHERS AND CO.—This firm send us particulars of their manufacture of "Standard" wood separable or split pulleys, which are known as the "Dodge" pulleys. Amongst the advantages claimed for these pulleys are their lightness and excellent belt surface. The list shows at a glance the cost of any diameter of pulley and width of face. The patent bushing system of pulleys associated with these pulleys consists of a simple method of bushing pulleys that may be utilised on shafts of various sizes.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

October 23, 1891.

18,199. A. MARR. Manchester. Improvements in and connected with telephone exchange switches.

18,207. A. T. COLLIER. Manchester. Improvements in electric telephones

18,251. SIEMENS BROS. AND CO., LTD., and F. G. BAILY. London. Improvements in electricity meters.

18,256. A. S. FORD. London. An improved process for the electro-deposition of metal upon the surface of glass, porcelain, china, earthenware, and other materials. (H. Pother, France).

October 24, 1891.

18,272. J. CHADWICK. Manchester. Improvements in electric belts for body wear.

18,285. A. BURTON. Birmingham. Improvements in electric switches.

18,290. A. P. LUNDBERG. London. Improvements in switches for electric lighting.

18,304. H. HIRST. London. An improved device for trueing the commutators of dynamo-electric machines.

18,318. G. L. HALL. London. An improved electrical safety-switch.

18,348. T. PARKER, J. H. WOODWARD, and E. S. G. REES. London. Improvements in and connected with the distribution of electricity.

October 26, 1891.

18,421. J. M. ORMES. London. A new or improved electric lighting system. (S. L. Trippe, United States).

October 27, 1891.

18,423. SIR C. S. FORBES (Baronet). London. An improved telephone combination.

18,431. M. WADDELL, J. B. ENTZ, and W. A. PHILLIPS. Manchester. Improvements in secondary batteries.

18,432. S. J. ROLLASON. London. A portable electric illuminating advertisement.

18,436. SIR W. THOMSON. Glasgow. Improved apparatus for measuring and recording electric currents.

18,451. A. R. BENNETT. London. Improvements in telephonic switching apparatus.

18,477. O. SCHLESINGER. London. A depolarizing liquid for galvanic batteries.

18,505. W. B. CLEVELAND. London. A new or improved electric circuit controller or appliance.

18,522. W. P. THOMPSON. Liverpool. Improved method of and apparatus for welding or working metals electrically. (C. L. Coffin, United States).

18,524. W. P. THOMPSON. Liverpool. Improvements in insulators or insulating supports for electric conductors. (R. Hewitt and F. L. Pope, United States.)

October 28, 1891.

18,534. A. MARR. Manchester. Improvements in electric telephonic instruments.

18,551. C. J. HALL. London. Improvements in or relating to electrical terminals.

18,595. H. T. HARRISON and G. W. BUDD. London. Improvements in electric meters.

18,597. E. ANDREOLI. London. Improvements in electrolysis.

October 29, 1891.

18,626. J. C. RICHARDSON. London. Improvements in the construction of electrodes, for use in the electrolysis of solutions

18,627. J. C. RICHARDSON. London. Improvements relating to electrodes to be used in the electrolysis of solutions.

18,629. W. T. GARNETT. Bradford. Improvements in electric-dynamos and motors.

18,641. B. F. KELLY. Birmingham. Improvements in electrical apparatus

18,646. H. CHITTY. Chiswick. Improvements in electric motors and dynamo machines.

18,650. The ELECTRICAL ACCESSORIES COMPANY, LIMITED. London. Improvements in electrical switches.

18,653. N. SHAGOURI and J. H. HALE. Bristol. Improvements in means, electrically operated, for retarding and arresting the motion of trains, applicable also to tramcars.

October 30, 1891.

18,714. F. E. GRIPPER and S. COYLE. London. Improvements in the regulation of gas and oil engines for electric lighting purposes.

18,716. A. WRIGHT. Brighton. Improvements in electricity meters.

18,723. C. S. SNELL and WOODHOUSE AND RAWSON UNITED, LIMITED. London. Improvements relating to resistance frames and the like used for electrical purposes.

18,726. A. MARR and A. T. COLLIER. Manchester. Improvements in the cores of electric coils.

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18,733. A. Marr and A. T. Collier. Manchester. Improvements in and connected with electric telephonic apparatus.

18,771. H. Pieper, Fils. London. Improvements in electric railway brakes.

18,775. Siemens Bros. and Company, Limited, G. S. Grimston and E. Perrett. London. Improvements in electric bell indicators.

October 31, 1891.

18,784. J. Swinburne and W. Fox-Bourne. Teddington. Improvements in electrical measuring instruments, dynamo-electric machines, registering instruments, and transformer switches.

18,801. T. H. Smith. Leeds. Improvements in electric arc lamps.

18,831. G. Cohen. Manchester. Improvements in magnetic electric hair-pins, curling pins, and similar articles.

18,834. A. Howison and W. J. Nelson. Manchester. A novel application of electricity to domestic purposes.

18,837. Siemens Bros. and Company, Limited. London. Improved means for supporting overhead electrical conductors round curves for electric railways or tramways. (Siemens and Halske, Germany).

November 2, 1891.

18,854. F. T. Schmidt. Bradford. Improvements in the construction of electrically controlled arc lamps.

18,855. W. S. Freeman. Otford. Improvements in dynamos and electric motors.

18,857. E. H. P. Humphreys. London. Improvements in meters for measuring electricity.

18,890. Siemens Bros. and Co. (Limited). London. Improvements in rotary phase current motors and dynamos.

18,897. R. Wood. London. Improvements in methods of apparatus for regulating the supply of electricity used for lighting, motive power or other purposes.

18,898. W. F. Taylor and G. J. Philpott. London. Improved insulating and protecting devices for concentric electric mains.

18,899. W. F. Taylor and G. J. Philpott. London. Improvements in electric meters.

18,902. G. F. Redfern. London. Improvements in the manufacture of tubular conduits for electric conductors. (S. Bergmann, Germany.)

18,905. J. O. y. Espinosa. London. Improvements in electric railway signals, part of which are applicable to other signalling or alarm purposes.

November 3, 1891.

18,916. R. D. Nuttall. Birmingham. Trollies for electric cars.

18,928. E. R. Dale. London. Improvements in the application of electricity to various useful purposes.

18,931. J. Pullmann and H. Lane. London. Improvements in apparatus and process for obtaining aluminium or other metals by means of electricity.

18,938. L. Langhans. London. Process for producing filaments for incandescent lamps.

18,974. T. Parker. London. Improvements in electrical furnaces for the manufacture of phosphorus or other matters capable of being volatilized by heat.

18,906. T. Parker and E. S. G. Rees. London. Improvements in arc electric lamps.

November 4, 1891.

19,020. A. R. Bennett. London. Improvements in telephonic switching apparatus.

19,047. J. Cerpaux. London. Improvements in and apparatus for reducing or condensing induction currents.

19,056. H. V. Weyde. London. Improvements in reflectors and appurtenances used in electric light photography.

19,071. R. Langhans. London. Improvements in the manufacture of wires for incandescent lamps, and in connecting the said wires to the filaments.

November 5, 1891.

19,134. F. Teague. London. Improvements in or relating to electric meters.

November 6, 1891.

19,162. A. M. Thompson and W. W. G. Webb. Chester. Electric meter.

19,176. E. A. Wahlström. London. Improvements in rotating magnetic fields, and in multiphase alternating currents.

19,190. E. W. Watling. London. A multiple terminal for electrical distribution.

19,198. A. G. New. London. Improvements in apparatus for placing electric lamps in circuit in any desired order or sequence.

19,211. F. Teague and E. F. Moy. London. Improvements in or relating to electric meters.

19,225. Siemens Bros. and Co. (Limited) and A. Schloemer. London. A polarised electrical indicator.

19,233. J. F. Munsie. London. Improvements in and relating to electric railways.

November 7, 1891.

19,314. H. H. Lake. London. Improvements in and relating to incandescent electric lamps. (La Société dite Electriciteits Maatschappij, System de Khotinsky, Germany.)

November 9, 1891.

19,339. R. J. H. Pippette, London. Facilitating the operations of switching usually carried on in telephone exchanges by means of an improved switching apparatus.

19,348. R. W. Brownhill, Birmingham. An attachment or means for electrical measuring, sale and delivery, or delivery with measurement only.

19,385. E. Francis, Nottingham. Electric lamps applied to bicycles, tricycles, and all velocipedes; also for carriages and any vehicle with or without apparatus to work the same.

November 10, 1891.

19,390. H. G. Read, Salford. Improvements in dynamo-electric machines, and apparatus appertaining thereto.

19,398. A. Hoster, London. Improvements in or relating to bases for electrical switches.

19,424. W. H Parry and J. Whitehead. Birmingham. Improvements in electric globe and shade holders.

19,450. T E. Marsh and Woodhouse and Rawson United (Limited). London. Improvements in electric apparatus.

19,458. W. P. Thompson. Liverpool. Improvements in electric accumulators or storage batteries. (N. H. Edgerton, United States.)

19,469. R. Grove and C. Lehr, Junior. London. Improved device for bringing the receiving instruments of telephones against the ears of the person speaking, and returning the same to their position of rest, as also for circuiting the telephone in and out.

19,495. J. J. Powers and R. Van Buren. London. Improvements in machines for making clay conduits for electrical and other purposes.

19,501. R. Woodley, J. Spear, and W. Harris. Hull. A process for solidifying steel, iron, or other material susceptible to magnetic influence by the application of electrical energy.

November 11, 1891.

19,503. A. A. Day. London. Improvements in apparatus for electric testing.

19504. F. Bryan. London. Improvements in holders for incandescent electric lamps.

19,546. W. Hartnell. Leeds. Improvements in alternating current dynamos.

19,551. A. R. Upward and A. G. Buttifant. London. Improvements in electrical means of advertising.

19,553. P. G. Lironi. London. Improvements in magneto-electric cut-outs, or safety apparatus.

19,554. P. G. Lironi. London. Improvements in electric switches.

19,617. M. Müthel. London. Improved exciting fluid for galvanic zinc carbon batteries.

19,625. A. Grundy. London. Improvements in ceiling roses and wall sockets for electric lighting.

19,630. G. G. M. Hardingham. London, Improvements in electric cables. (Messrs. Felten and Guilleaume, Germany).

19,635. H. Count Von Pückler. London. An improved electric apparatus for alluring and destroying insects.

November 13, 1891.

19,666. C. P. Shrewsbury. London. Improvement in and connected with the application and utilisation of electricity in the driving of machinery, locomotion, and like uses.

19,667. C. P. Shrewsbury. London. An improvement in lamps or apparatus connected with electric lighting.

19,691. J. C. Lawson. London. An improved device for ozonising air or gas by means of electricity.

19,704. J. C. Richardson. London. Improvements relating to the application of depolarisers in electrolysis.

19,716. J. Von Orlowsky. London. Improved polar fastening for galvanic elements.

19,744. E. W. Smith. London. Improvements in alternating-current machinery.

19,775. A. Brener. London. Improvements in diaphragms for electrolytic decomposing apparatus.

19,778. R. A. Dawbarn. London. Improvements in electric lighting apparatus.

November 16, 1891.

19,824. W. G. Potter and C. Midgeley. Nottingham. Electric spiral lamp for general lighting purposes, for railway carriages, tramcars, and cabs.

19,835. W. A. Crook and H. J. Payne. Barnes. Improvements in gravity control, as applied to electric measuring instruments.

19,854. J. Dickson and R. G. Shapcott. London. Improvements in dynamo brushes.

November 17, 1891.

19,895. J. Atkinson. London. Improvements in incandescent electrical lamps.

19,899. T. Weighill. Liverpool. Improvements in telephone closets and other structures where it is desirable that they should be practically sound proof.

19,900. W. P. Thompson. Liverpool. Improvements in or relating to welding or working metals electrically. (C. L. Coffin, United States.)

19,909. A. Marr. Manchester. Improvements in telephonic transmitters.

19,914. J. B. Barton. London. Improvements in or connected with electric arc lamps. (W. Jandus, United States.)

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19,919. W. G. Potter and C. Midgeley. Nottingham. An electric lamp for lighting and signalling at sea and land and for deep sea fishing.
19,926. W. G. Potter and C. Midgeley. Nottingham. An electric cable seating for laying in the cable for house-to house supply for laying in the wires.
19,952. W. D. Hoffman. London. Improvements in magnetic separators.
19,965. J. C. Love. London. Improvements in and relating to conduits for electric conductors.
19,968. M. C. Burt. London. Improvements in electric motors and dynamos.
19,971. E. L. Mayer. London. Improvements in or connected with electrical measuring and indicating apparatus.
19,972. E. L. Mayer. London. A new or improved device for varying the resistance in telephone circuits.
19,975. F. P. Maquaire. Paris. Improvements in and relating to electric arc lamps or lighting apparatus.

November 18, 1891.

19,996. J. Nicholls. Leeds. Improvements in electric alarum clocks.
20,026. G. A. Nussbaum. London. Improvements in multiple switch-boards for telephone exchanges. (L. Mandroux, France.)
20,033. S. D. Williams. Newport. Improvements dynamo-electric machines.
20,059. J. Hutchinson. London. An electric gondola.

November 19 1891.

20,078. R. Gay and W. H. Jackson. Halifax. An improved automatic and electric check-till.
20,109. W. H. Sturge. Birmingham. Improvements in electric switches.
20,111. J. H. Rider. Halifax. Improvements in methods of electrical distribution.

SPECIFICATIONS PUBLISHED.

1890.

19,034. Jones and others. Electrical testing apparatus. (Price 6d.)
20,698. Leigh. (Desroziers.) Dynamo-electric machines. (Price 8d.)
21,116. Gay and Hammond. Electric arc lamps. (Price 8d.)
21,224. Abel. (Société Générale des Telephones and another). Telephonic circuits. (Price 8d.)

1891.

60. Clamond. Incandescence gas lamps. (Price 8d.)
1,069. Brookes and Ward. Gas, electric light, &c., lamps. (Price 8d.)
1,905. Atkinson. Distributing electric currents. (Price 8d.)
12,799. Feilbogen. Electric distribution. (Price 6d.)
13,503. Dobrowolsky and others. Electric machines, &c. (Price 11d.)
14,388. Dymond. (Gutmann). Electric motors. (Price 8d.)
14,663. Shiels. Connecting electric wires. (Price 8d.)
14,764. Thompson. (McLaughlin). Dynamo-electric generators, &c. (Price 8d.)
16,522. Thompson. (Coffin). Electrically soldering metal. (Price 6d.)
16,526. Lake. (Tweedy). Electric arc lamps. (Price 4d.)

NEW COMPANIES, STATUTORY RETURNS, &c.

AUTOMATIC GAS-LAMP LIGHTER COMPANY (LIMITED).—This Company was registered on December 7, 1891, with a capital of £6,000, in £1 shares, by Church, Rendell, Todd and Co., 9, Bedford-row, W.C. The objects are to acquire the benefit of a certain existing invention, No. 19,417 of 1890, for "Improved apparatus for automatically lighting and extinguishing street and other gas lamps," and to carry on the business of mechanical, gas, or electrical engineers, machinists, brass and iron founders, &c.

D. W. FORBES AND CO. (LIMITED).—This Company was registered on December 1, 1891, with a capital of £25,000, in £5 shares, by S. H. Peddar, 4, Palmerston-buildings, Old Broad-street, E.C. The objects are: To acquire and carry on the Smithfield Engineering Works, Blackwall, London, and to carry on the business of engineers, coppersmiths, iron and tin plate workers, shipchandlers, millwrights, manufacturers of cranes, engines, motors, and machinery, bridge builders, boiler makers, electric engineers, and manufacturers of electric apparatus, machinery, plant, and appliances, &c.

J. MURGATROYD AND CO. (LIMITED).—This Company was registered on December 1, 1891, with a capital of £5,000, in £5 shares, by Jordan and Sons, 120, Chancery-lane, London, W.C. The objects are to acquire and carry on the business of engineer, coppersmith, brassfounder and finisher, carried on by James Murgatroyd at the Standard Works, Lymm, Cheshire. Registered without Articles of Association. Registered office: High-street, School Brow, Warrington, Lancashire.

"LIGHTNING" (LIMITED).—This Company was registered on December 2, 1891, with a capital of £3,000, in £1 shares, by Slaughter and May, 21, Great Winchester-street, E.C. The objects are to establish, print, and publish newspapers, magazines, books, plans, and drawings of every description.

LONDON AND BIRMINGHAM MANUFACTURING COMPANY (LIMITED).—This Company was registered on December 1, 1891, with a capital of £15,000, in £5 shares, by Roscoe and Hincks, 23. Christopher-street, Finsbury-square, E.C. The objects are to carry on the business of manufacturing and furnishing ironmongers, ironfounders, brassfounders, engineering tool makers, and electrical engineers, &c., carried on by W. F Reynolds and J. Burford. Registered office: 39, Upper Thames-street E C.

BICESTER ELECTRICITY SUPPLY COMPANY (LIMITED).—This Company, which was registered on November 2, 1891, with a capital of £5,000 in £5 shares, has its registered office situate at the Market Hill, Bicester in the county of Oxford.

ELECTRIC WELDING COMPANY (LIMITED).—The following was filed on December 2, 1891. In the High Court of Justice, Chancery Division, Mr. Justice Romer, for Mr. Justice Stirling, at Chambers, Monday, November 23, 1891. In the matter of the Companies' Act, 1862, and in the matter of the Electric Welding Company (Limited). Upon the application by originating summons, dated October 8, 1891, of Thorndike Nourse, of 2, Austin Friars, in the City of London, financial agent, and upon hearing the solicitors for the applicant, and for the above-named Company, and upon reading the affidavit of the said Thorndike Nourse, filed October 23, 1891, and the exhibit therein referred to, and the affidavit of Arthur John Davis, filed November 25, 1891, and by consent. It is ordered that the register of shareholders of the said Electric Welding Company (Limited) be rectified by removing therefrom the name of the said Thorndike Nourse as the holder of one founders' share and 49 ordinary shares in the said Company; and it is ordered that notice of this order be given to the Registrar of Joint-Stock Companies by leaving a copy thereof with him; and it is ordered that the said Electric Welding Company (Limited) pay to the said Thorndike Nourse the sum of £11. 17s. 8d., being his ascertained costs of this application. Messrs. Snell, Son and Greenup, 1 and 2, George-street, Mansion House, E.C., solicitors for Thorndike Nourse. Registered office of the above-named Company: 6, Great George street, Westminster, S.W.

GENERAL ELECTRIC COMPANY (LIMITED).—The annual return of the above-named Company, made up to November 30, 1891, was filed on the following day. The Company was registered on July 25, 1891, with a capital of £60,000, divided into 7,000 First Preference, 1,000 Second Preference, and 4,000 ordinary shares of £5 each; 11,325 out of the 12,000 shares have been taken up, and upon 6,325 the full amount has been called and paid. The 4,000 ordinary and the 1,000 Second Preference shares were issued as fully paid. Gustav Binswanger, the Managing Director, holds 2,250 First Preference, 1,000 Second Preference, and 2,000 ordinary shares. Ferdinand Heys, of 7, Lothbury, holds 750 First Preference and 500 ordinary shares. Benjamin Newgass and Otto H. Edinger, of 7, Lothbury, E.C., jointly hold 1,496 First Preference and 450 ordinary shares. Registered office: 71, Queen Victoria-street, E.C.

ISLE OF WIGHT ELECTRIC LIGHTING COMPANY (LIMITED).—The registered office of this Company, which was registered on November 12, 1891, with a capital of £1,000 in £1 shares, was filed on December 4, 1891, and is situate at 21, Lime-street, London, E.C.

CITY NOTES, &c.

CHILI TELEPHONE COMPANY (LIMITED).—The Stock Exchange Committee have ordered shares Nos. 1 to 40,000 of this Company to be quoted in the Official List.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts of this Company for the week ended December 6th amounted to £310; aggregate receipts for half-year to date, £16,753.

COMMERCIAL CABLE COMPANY.—This Company officially announce the payment on January 2, 1892, of the usual quarterly dividend at the rate of 7 per cent. per annum. It is further announced that the drawing of bonds to take place this month for repayment in January will again be at the maximum of £120,000. The outstanding bonds will thereby be reduced to £200,000.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of November show a decrease of £7, as compared with the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of November were £2,235, as compared with £2,722 in the corresponding period of last year, showing a decrease of £487.

GREAT NORTHERN TELEGRAPH COMPANY (LIMITED).—The traffic returns of this Company in November, 1891, were £22,400; January 1st to November 30th, £260,200; corresponding months, 1890, £256,400; 1889, £252,400.

RICHARD HORNSBY AND SONS.—THE ELECTRICAL EXHIBITION AT THE CRYSTAL PALACE.—At the ordinary general meeting of this Company held on Wednesday, the 9th inst., Mr. James Hornsby, the Chairman, in the course of his remarks, said: In our engineering department we have been nearly as busy as last year, having obtained some good orders for electric lighting engines, together with an increased demand for most of our other engines. In this connection I may mention that we are supplying the whole of the motive power for generating the electrical energy to be used at the forthcoming Electrical Exhibition at the Crystal Palace, the plant being actually purchased, and afterwards to be used by a local company for the electric lighting of the neighbouring district. I hope that our

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shareholders and their friends who visit the Exhibition will take the opportunity of seeing the five large engines and boilers supplied by us, which are erected at Upper Sydenham, about a mile from the Palace. The report was adopted.

NATIONAL TELEPHONE COMPANY (LIMITED).—The Directors have resolved to declare an interim dividend for the six months ended October 31st last at the rate of 6 per cent. per annum (less income-tax) on the first and second preference shares, and at the rate of 5 per cent. per annum (less income-tax) on the ordinary shares of the Company. The transfer books will be closed from the 7th to the 18th inst., and the dividend warrants will be posted on the evening of the latter date.

ST. PANCRAS VESTRY.—This Vestry invite tenders for a loan of £60,000, for electric lighting works, on the security of the parish rates. Tenders are to be sent to Mr. T. E. Gibb, the vestry clerk, on or before Tuesday, December 15th.

CRICKET.—EASTERN EXILES *v.* AMBER.—A cricket match was played at Malta on the 2nd inst. between the members of the ship and shore staff of the Eastern Telegraph Company, resulting in a victory for the mariners by 54 runs. Scores:—

EASTERN EXILES.—Saunders, c Cottrell b Pickett, 26; Sweeting, b Pickett, 1; Bean, b Pickett, 0; Corston, c Smith b Pickett, 3; Devitt, b Theobalds, 2; Sherlock, b Pickett, 8; Costen, not out, 27; Mitchell, b Pickett, 0; Baines, b Pickett, 12; A. Nosworthy, b Theobalds, 6; F. Nosworthy, b Pickett, 2; extras, 16; total, 95.

AMBER.—Mitchell, c and b Saunders, 3; Gibbs, b Saunders, 10; Robb, c Bean b Saunders, 12; Lack, b Saunders, 1; Cottrell, b F. Nosworthy, 61; Theobalds, b F. Nosworthy, 16; Pickett, b Saunders, 12; Ryan, b F. Nosworthy, 12; Smith, b F. Nosworthy, 11; Ladds, not out, 0; Gifford, c Bean, b F. Nosworthy, 0; extras, 11; total, 149.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Dec. 2		Price Wednesday, Dec. 9.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Dec. 9.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/6	Anglo-American	49	50	49	50	5 1 0	Jan., Apr., July, Oct	49½	49½
£2,849,510	Stock	25/0	Do. Preferred	87	88	87½	88½	5 15 10	" "	88½	87½
£2,849,510	Stock	5/0	Do. Deferred	12	12½	12¼	12¾	..	" "	12⅝	12¼
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	..	..
130,000	£10	5/0	Brazilian Submarine	10¾	11½	11	11½	7 2 3	Mar., June, Oct., Dec.	11⅜	1¼
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	145	148	145	148	4 14 7	April and October	150	11½
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	16	17	16	17	5 17 8	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½	3¾	3½	3¾	6 18 8	April and October	3⅜	..
6,000	5	10%	Do. Preference 10%	9½	10½	9½	10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10¾	11	10¾	11	6 7 3	Jan., Apr., July, Oct	11	10¾
400,000	10	2/6	Eastern	14	14¼	14	14¼	4 11 3	" "	14¼	14
70,000	10	6%	Do. 6 per Cent. Preference	14¾	15½	14¾	15½	3 18 8	" "	15	14¼
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	108	107½
250,000	10	2/6	Eastern Extension	15	15½	15	15½	4 12 7	Jan., Apr., July, Oct.	15 1/16	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107	110	107	110	3 12 9	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July	106	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	102	105	102	105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	98	101	98	101	3 19 3	Febuary and August	..	..
180,227	10	2/0	Globe Telegraph and Trust	9⅝	9⅞	9⅝	9⅞	5 8 10	Jan., Apr., July, Oct.	9⅞	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	14⅝	14⅞	14⅜	15	4 0 0	" "	15	14⅜
150,000	10	5/0	Great Northern	18½	19	18¾	19¼	4 8 4	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	106	..
9,000	8	4/0	Reuter's	7¾	8½	7¾	8½	4 16 11	April and October	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	117	122	115	120	5 0 0	" "	117	115½
15,609	10	6/0	West African Telegraph	7½	8½	7½	8½	5 17 8	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	97	100	97	100	5 0 0	March & September	99	..
30,000	10	2/0	West Coast of America	3	4	3½	4½	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	97	102	99	104	7 13 10	June and December	..	..
88,321	10	1/0	West India and Panama	1½	1⅝	1½	1⅝	..	" "	1 3/16	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9	9½	8¾	9¼	6 9 9	May and November	9¼	9
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7½	8½	7	8	7 10 0	" "	7½	..
17,007	15	6/0	Western and Brazilian	10	10½	10¼	10⅝	6 19 5	" "	10⅜	10¼
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6¼	6⅝	6¼	6⅝	5 7 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	3⅞	4¼	4	4½	..	" "	4¼	4 1/16
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜	½	⅜	½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16	1/16	1/16	1/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅜	4⅝	4⅜	4⅝	6 9 9	June and December	4 3/16	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13	12½	13	4 12 4	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Prf. (£10 pd or fully pd)	12	13	12	13	3 14 1	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	107	109	107	109	4 2 7	January and July	108¼	108½
58,000	5	1/0	United River Plate	1	2	1	2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
31,152	£10	..	City of London Electric Lighting (£6 paid)	4½	5½	4½	5½	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
8,332	£5	..	House to House Electric	4½	5	4½	5	..	..	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2¾	2¾	2¾	2¾	..	..	..	..
10,000	£5	3½%	Do. (fully paid)	4¾	5¼	4¾	5¼	..	..	5	..
111,000	5	..	London Electric Supply	1½	1⅝	1½	1⅝	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9¾	10¼	9¾	1⅛	..	..	10 1/16	9¾
6,318	10	..	Notting Hill Electric Lighting (fully paid)	6	7	6¾	7¾	..	..	..	..
18,680	£5	3/6	St. James' and Pall Mall	8¾	9¼	8¾	9¼	..	..	8⅞	..
7,900	£5	7%	Do. 7% Preference	7	7½	7¼	7¾	..	..	7½	7¼
42,853	5	..	Westminster Electric Supply (£5 paid)	6½	6¾	6¼	6¾	..	..	6 1/16	6⅜
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/8	Brush Electrical Engineering	3	3¼	3¼	3½	5 10 10	..	3½	3¼
69,996	2	6%	Do. 6 per Cent. Preference	2	2¼	2	2¼	5 6 8	..	2¼	2
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼	5¾	5¼	5¾	6 1 9	January and July	5½	5 1/16
17,130	5	17%	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	6%	Electric Construction	6½	7	6	7	..	—	6 15/16	5¼
70,000	2	10/0	Elmore's Patent Copper Depositing	3¼	3½	2⅝	3⅛	..	—	3⅜	2 13/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20½	21½	20½	21½	4 15 3	February & August	21	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	104⅜	..
11,334	£10	6/4	International Okonite Limited Ordinary	5	6	5	6	..	..	..	..
11,334	£10	8/0	Do. Preference	8¾	9¼	8¾	9¼	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛	⅜	⅛	⅜	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	4⅛	4⅜	4⅛	4⅜	8 2 0	May and November	4 1/16	4⅛
36,250	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July	43¼	42⅝
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2⅛	2⅜	2⅛	2⅜	15 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	3⅜	3⅝	3⅜	3⅝	10 0 0	..	..	..
			RAILWAYS AND TRAMAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	—	—
60,000	£10	..	City and South London Railway	3	5	3	..	—	—	—	—

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THE ELECTRICIAN:

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NOTES.

At a recent meeting of the New York Electric Club a most intereresting Paper was read by Mr. E. Rosewater upon the Government telegraphs of Europe; and an unusually long editorial comment is made upon it in the *Electrical World* of New York for December 12. It is there pointed out that while the German telegraph system has been much lauded, the German Government railway system and the Government cigars and tobacco are not brilliant examples of State monopolies. Mr. Rosewater observes that with one-half of the world's telegraphic line mileage American companies handled only 60,000,000 telegrams in 1889 against 204,935,055 telegrams handled in European countries alone, while Great Britain, with less than one-third of the wire mileage of the United States, handled 63,403,399 messages that year. The author of the Paper thinks it worth mentioning that the chief operator in a Welsh office declared most emphatically that he was a Radical, and decidedly opposed to the present Conservative party in power, and that a number of the operators in his office were either Radicals or Liberals; but if the Postmaster, who has supreme control of the telegraph force, dared to dictate what ticket they should vote, or undertake to interfere in any way with their rights as citizens, they should soon have a Parliamentary inquiry, and the Postmaster would soon find himself dismissed in disgrace. Such a thing, he adds, as trying to delay a political message, or tamper with it, or divulge its contents, has never been heard of in France.

Shipping disasters along the British coasts are following one upon another in quick succession, and the lesson we have preached for years past on the necessity of electrical communication with outlying lightships, and between all lighthouses and lifeboat stations, has been tragically illustrated by the casualties of the last few weeks. The terrible story recounted in *The Times* on Tuesday is only one of many that might be told pointing the same moral, though it may be hoped that none have had to tell of such suffering and loss of life. Within sight of the Galloper lightship the "Enterkin" merchantman was driven on the North Galloper Sands and dashed to pieces, only one of the crew being rescued by a passing fishing smack many hours afterwards, the lightship having no means of giving information to the shore as to the locality of the wreck. Two other men were picked up by an Antwerp steamer; and these are all that survived out of a crew of 30. We can only echo the words of *The Times* on this humiliating incident, that these brave men may not have died in vain, and that at last the national duty may be recognised of providing not merely warning of darger but succour when warning is of no avail.

While the alternate-current system of electric lighting is supposed to be specially applicable for pioneering work, the advocates of low-pressure distribution seem to get the ear of Town Councils, who sometimes never examine any other methods or invite competition. A town councillor, writing to a local paper on the electric lighting of an important suburb of London, remarks that the Committee of the Town Council entertain an opinion of the wisdom, the ability, and the disinterestedness of the contractors, that is something beyond what ordinary mortals are entitled to, and that they look upon the consulting engineer as a heaven-born genius; and the two in conjunction produce an amalgam which they consider it ill-conditioned rashness, if not sacrilege, to criticise. Modestly intimating that his knowledge is embryonic, he concludes his letter with a confident statement that a cheap supply is possible. "It is easy enough of attainment, for the electric fluid itself costs nothing; it is only the energy that is necessary to send it to the point where it is to be used that makes the largest item of expense." This remark is more accurate than might be expected from any one who uses the expression "electric fluid." In the leading article of our present issue we have questioned whether this fluid exists; and a good authority stated in the witness-box last week that "volts cannot be bought." The town councillor is perfectly right in his contention that it is only the energy that costs the money, and, with a slight verbal modification, his conclusion is thoroughly scientific.

The following letter is a sample of a suggestion which turns up every few months. We hesitated at first as to whether it should be printed in full in our correspondence columns, since it was not marked "private," but decided that it would be a mistake to give advertisement to such a firm. Sometimes we are offered illustrated abstracts of new patents, but a regular cash payment of £1 a month is something novel. A very large number of inventions are patented by the inventors themselves, since the facilities for doing so have been so greatly increased. The principle that he who is his own lawyer has a fool for his client is well known; but patents are often applied for by inventors on another principle, namely, throw enough mud, and some of it will stick. Any one having an invention

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which promises to be really valuable should take it to a regular patent agent, and the additional sum spent on the fees of the leading members of the profession are quite trifling compared with the expenses of bringing out an important invention. In the absence of a strong recommendation, an inventor had better go to some firm of patent agents a member of which is a Fellow of the Chartered Institute of Patent Agents. It is hardly necessary to say that the following letter comes from no such firm :—

TO THE EDITOR OF THE ELECTRICIAN.

"————" and Co., Patent Agents, —, Chancery-lane, London,
Telegraphic Address, "————," London. W.C., Dec. 15, 1891.

DEAR SIR : We take the liberty of asking if we could make arrangements with you for being Patent Editors to your paper. Our suggestion is that you should insert a short paragraph among the matter of your paper as follows :—"If any of our readers have an idea for an invention they may have full particulars about patents and inventions *free* from our Patent Editor. Send stamped envelope." You would receive all letters and open same, should you wish it, and we would send for them and forward required answers. We believe it would be very useful to your readers and beneficial to us, and we are willing to pay you £1 per month for such Patent Editorship. We are Patent Editors in this way to "————," "————," "————," "————," "————," "————," "————," "————," and shall be pleased to be the same to your paper. We enclose you our pamphlet on patents, in which you will see the various papers we have dealings with. Our Mr. ———— will be pleased to call upon you any time by appointment to more clearly explain this system of giving Patent information, which has been entirely inaugurated by us.—Yours faithfully, ———— and Co.

OUR Paris correspondent is able to announce this week that the new year will witness the birth of yet another electrical journal. *L'Industrie Electrique*, as our Paris contemporary is to be christened, will be under the ægis of M. HOSPITALIER, and we may therefore expect the admirable lucidity of style which characterised the old *Electricien* ; but the equally commendable conciseness and compactness of that organ will, we fear, be wanting. *L'Industrie Electrique* proposes, like a true nineteenth century production, to be *big*.

IN the same letter our Paris correspondent also states that M. HEILMANN has found several spirits as bold as himself to subscribe 300,000 francs towards the expense of a practical test of his electric locomotive. M. HEILMANN'S idea is to mount a triple expansion engine on wheels, which shall drive a dynamo supplying "polyphase" currents to appropriate motors placed direct on the axle. At the other end of the scale we have the announcement that the firm of BRÉGUET have just completed an "accumulator locomotive" for a railway company. It is difficult to say which scheme seems the more lacking in practicability.

THE manners and customs of Englishmen differ so widely from those of Frenchmen, especially during their hours of leisure, that the great success which has met the "theatrophone" in Paris cannot be accepted even approximately as an indication of the demand which may be made by Londoners for sixpenny or shilling snatches of operas. Should Mr. SZARVADY find that his very ingenious instrument is not sufficiently well patronised by the frivolous, we would suggest that he should turn his attention to the House of Commons, the Law Courts, or the London County Council. The automatic indicator in front of the instrument, instead of giving the name of the theatre, should show "Overhead Wires Bill—Hicks-Beach," or "Brush *v.* King Brown—Moulton," or "Municipal Electric Lighting—Burns."

Fire at the Khotinsky Glow-Lamp Factory.—On the 2nd inst. a fire occurred at the Khotinsky glow-lamp works at Glenhausen.

Cardiff.—The Lighting Committee have decided to defer the application for a Provisional Order permitting them to light the town by electricity.

Electric Lighting of Omnibuses in Berlin.—According to the *Elektrotechnische Rundschau*, the Berlin General Omnibus Company is about to try lighting their rolling stock by electricity.

Cable Repairs.—The Société Française des Télégraphes Sous-Marins inform us that their cable between Cayenne and Vizeu, which has been interrupted since October 22nd, was repaired on December 1st.

St. Pancras Vestry.—The Prudential Assurance Company has offered to advance £60,000 at 3½ per cent. interest for 42 years to the St. Pancras Vestry in connection with its electric lighting scheme.

Domestic Telephones.—At the Adelphi Hotel, Liverpool, which has lately been renovated, a complete system of telephonic inter-communication between one visitor and another, and between all visitors and the hotel staff, has been installed.

Plymouth.—At a recent meeting of the County Council it was decided to ascertain the desirability or otherwise of obtaining powers for lighting the borough by electricity, and also whether water power could be made available for generating electricity.

The Electrical Utilisation of Water-Power at Marburg.—A project is on foot, suggested by the success of the Lauffen-Frankfort experiment, for conveying 600 H.P. by electricity from Marburg to St. Lorenzen, a distance of 18 miles. A head of water, over 200ft., is available at the former place.

Bradford.—At the monthly meeting of the Town Council, on Tuesday last, the Gas and Electricity Supply Committee recommended the Council to direct that all necessary steps shall be taken for extending the area so as to include the district of Allerton. The recommendation was agreed to.

Mutual Telephone Company.—There are now over 830 subscribers to the Mutual Telephone Company in Manchester. The system is being extended by the erection of trunk lines between Manchester, Farnworth, and Bolton. It is expected that these will be completed by the end of the present month.

Sheffield.—The General Purposes and Parks Committee of the Town Council at their last meeting resolved to recommend the Council to adopt electric light for the Council Chamber, and to accept the tender of the Sheffield Telephone Exchange and Electric Light Company to fix a sufficient number of lamps to light it efficiently.

Mica.—A mica discovery is now reported from Natal. The extent of the bed has still to be proved, but it has been stripped for a length of 100ft. and to a depth of 30ft. The mica occurs in small pockets, and ranges in size from about 8in. in length by 4in. in breadth on the surface. At a depth of 27ft. the mica is very short and the cleavage very imperfect.

Vienna Street Traffic.—In view of the agitation for the construction of an electric "Metropolitan" railway, it may be interesting to note that according to Herr Prasch, Inspector of Telegraphs, the internal traffic of Vienna is relatively only half as intense as that of London, a fact, which is, he thinks, largely attributable to the lack of rapid transit.

Electricity in Calico Printing.—La Société Industrielle de Mulhouse are offering, amongst others, a silver medal for the application, in any form, of electricity to calico printing. Full

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particulars regarding the competition can be obtained by applying to the Society, and all applications for the awards should be sent in on or before February 15, 1892.

The Telephone in Costa Rica.—A Belgian firm has been granted a concession for erecting telephone exchanges in the Republic of Costa Rica, to be connected together by trunk wires. Some of the existing telegraph lines will be employed as interurban telephone wires by the adoption of the Van Ryssel-berghe system. Dejongh transmitters and Bell receivers will be employed.

Electric Lighting on Railways.—The Directors of the San Paulo (Brazilian) Railway Company, in their report just issued, announce that plant for the electric lighting of the new goods yard at Pary has been sent out, and that they have ordered the necessary plant for lighting the Serra inclines by electricity, so that they may be worked by night, and thus increase the capacity of the line.

Weston-super-Mare.—At the last monthly meeting of the Town Commissioners, the taxed costs in connection with the Weston-super-Mare Electric Provisional Order, 1891, were reported to be £370. 13s. 11d. A sub-committee was authorised to visit such towns where electric light had been adopted for public and private purposes, and to obtain all information on the subject.

The Sims-Edison Torpedo.—A trial of the Sims-Edison dirigible torpedo was made on Tuesday on the Tyne at Newcastle before Sir William G. Armstrong, Mitchell, and Co. This trial was made to demonstrate the practicability of launching a dirigible torpedo from a ship in motion, and notwithstanding very bad weather, rain and fog, it seemed eminently satisfactory. An exhibition will shortly be given before the Lords of the Admiralty at Stokes Bay.

The Electrical Standardising, Testing, and Training Institution.—The library of this Institution was the scene of a very interesting ceremony on Monday last, when the First Year Students took the opportunity of presenting Mr. H. Doyer, the Demonstrator, who is leaving at the end of the year, with complete sets of Sir William Siemens' and Joseph Henry's works, as a mark of their respect for him, and, at the same time, of expressing their good wishes for his future.

The Berlin-Königsberg Trunk Wire.—According to the *Elektrotechnische Zeitschrift* the project for connecting these two towns by telephone will be carried out next spring. The length of the line from Berlin to Dantzig will be about 260 miles, and from Dantzig to Königsberg about 100 miles, making a total of 360 miles. The longest line in Germany at present is that from Berlin to Breslau, 220 miles, and after this comes the Berlin-Hamburg line, with a length of 170 miles.

Singapore.—The question of lighting Singapore by the electric light is, we understand, receiving attention. Gas is very expensive, and the introduction of the electric light has to meet with the opposition of the Municipal authorities, many of whom are interested in the gas companies. Owing to the large sums of money required for what is known as "military contribution," this colony's treasury is considerably drained, but we understand the prospects of introducing the electric light are favourable.

The City and Guilds of London Institute.—The prizes and certificates won in the City and Guilds of London Institute for the Advancement of Technical Education were distributed in Salters' Hall, St. Swithin's-lane, on Monday evening. The Lord Mayor presided, and among those present were Sir George R. Bruce (past president of the Society of Civil Engineers), Sir Frederick Abel, Sir Owen Roberts, Sir Philip Magnus, Sir Sydney Waterlow, Mr. H. C. Saunders, Q.C., Mr. Daniel Watney, Prof. W. C. Unwin, and Prof. Silvanus Thompson.

Iron Rail Telegraph Posts.—The Great Indian Peninsula, says the *Engineer*, is utilising old rails as telegraph posts, and they are cheap and durable, as well as strong and inflexible. An extra piece of rail is bolted to the rail at its lower extremity, generally from 4ft. to 6ft. long for an ordinary telegraph post. Sometimes two pieces are necessary for specially long poles. This end is then buried in the ground, and the pole is ready for its fixings. The cost is about from eight to ten rupees each as against from at least twenty to thirty rupees for wooden posts, and even more for galvanised iron uprights.

Old Students' Association.—On Wednesday last a meeting of this Association was held at Finsbury Technical College, when Mr. Rollo Appleyard read a Paper on "The Measurement of the Resistance of Conductors containing Disturbing E.M.F." He gave results of a number of experiments, when the tangent galvanometer method of measuring earth-plate resistance was used, and showed that this method often leads to erroneous results. On the other hand, by using a Wheatstone bridge, furnished with a special key (keeping *all* the circuits open until it is depressed), he was enabled to obtain results which did not greatly differ on various dates.

Magnetic Properties of Liquid Oxygen.—Prof. Dewar made last week a highly interesting communication to the Royal Society. He sought to determine what effect a temperature of − 180°C. would have upon the behaviour of liquid oxygen in the magnetic field. Having previously ascertained that liquid oxygen does not moisten or adhere to rock crystal, and consequently maintains in contact with that substance a perfect spheroidal condition, he poured the liquefied gas into a shallow saucer of rock crystal, and placed it between the poles of the Faraday electro-magnet. On the magnet being excited, the whole mass of liquid adhered to the poles until dissipated.

Electric Lighting of the County Council's Offices.—At the last meeting of the London County Council the Committee reported that they had authorised the connection of the installation with the mains of two supply companies being put in hand at once; and that they had accepted the estimate of the London Electric Supply Corporation for low-tension mains from their Red Lion Yard station; and the estimate of Messrs. Mather and Platt for the Electric Supply Corporation. The Committee asked that the course taken should be approved, which was agreed to. The tenders for the installation work were opened by the Council, and are given in our Trade Notes column.

The Trolley Wire.—"The latest trolley wire sensation," says the *Electrical World*, "hails from Pittsburgh, and furnishes a beautiful illustration of the singularly true remark made not long since that to those working around electric wires gravity is far more dangerous than the current. A steam fitter at work in a railway power station undertook to drive a nail and struck a trolley wire; the shock threw him from the ladder on which he was perched, and the fall produced a fracture at the base of the skull, from which he soon died. To this statement of facts the reporter with the agile imagination blandly added, 'it is supposed, however, that he was dead before he reached the ground.'"

The Specification of Insulated Conductors.—A Correction.—On p. 146 of our last issue the formula given by Mr. Preece for the *specific insulation* (σ) of any insulating material should read as follows:—

$$\sigma = \frac{R' l 2\pi}{\log_\epsilon D/d},$$

where R′ is the resistance in C.G.S. units of the dielectric of a cable whose length is l cms., and whose insulating sheathing has inner and outer diameter of d and D respectively (D and d being in any units). In the same manner R′ must be substituted for ρ in Mr. Kempe's simple approximate formula on p. 147, which thus becomes $\sigma = R' l \times \frac{d+t}{t}$.

Taunton.—At a recent meeting of the Town Council, the Watch, Lighting, and General Purposes Committee advised that negotiations be entered into with the Gas and Electric Lighting Companies for the acquisition of their undertakings. Alderman Van Trump, in moving the adoption of the report, said there was no doubt there would be some difference of opinion on the matter, as was the case when the town purchased the waterworks. The town was now deriving a handsome profit from the waterworks property, and he ventured to think, if the terms were anything like favourable, that the gasworks would also be a useful source of income, and the electric lighting would be no drag on them. The report was then adopted in full.

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Long-Distance Telephone Lines.—At present, says the *Chemical Trade Journal*, the American Bell Telephone Company of Boston has under way 50 long-distance telephone lines from Chicago to New York. Each of these lines takes two wires, making 100 lines of single wire, and as the distance from New York to Chicago is about 980 miles, the length of wire used in connecting these two points would be 98,000 miles. The size of the copper wire used in the construction of the long-distance telephone weighs 174lb. to the mile, making the total weight of the copper turned into wire for this one undertaking 17,052,000lb., or 8,526 tons, or 3,000,000lb. more than the total production of the Tamarack for the last year, or within about 1,800,000lb. of the combined output of the Quincy, Osceola, and Franklin; or, omitting the Calumet and Hecla, Tamarack, and Quincy, more copper than the remaining combined Lake Superior copper mines produced in 1890.

The Telegraph Line to Gilgit (Kashmir).—The problem of connecting Srinagar with Gilgit by telegraph is (says the *Indian Engineer*) one which is likely to tax to the full the ingenuity and scientific knowledge of Mr. Brooke's officers. To show the difficulties likely to be experienced, we have only to refer to the last report of the Telegraph Department. It is therein stated that in December and January exceptionally heavy snow caused long interruptions between Murree and Kashmir, Goragali and Rawalpindi, respectively, and also between Bakloh and Dalhousie. With regard to that between Murree and Kashmir, "the snow was so deep that the line was completely buried in places, and although troops were employed to assist in the work of clearing, the task proved too severe." If casualties of this kind occur in the comparatively low hills beyond Murree, it may readily be imagined how hard will be the task of keeping open communication over the snowy ranges between Srinagar and Gilgit.

Telephonic Fire Alarms.—At a recent meeting of the Leeds Corporation Fire Brigade Committee it was suggested that the extensive means of telephonic communication now existing in the borough might be utilised much more usefully than were the street fire alarms by which the brigade were frequently summoned to fires. These street-side apparatus were often subject to misuse. It was thought that ten or a dozen residents or firms might be found upon whose premises were telephones, with persons in charge thereof, who would permit indicators to be placed in prominent positions outside their houses or works, stating that the telephones within were available for any of the purposes already alluded to. In the course of the discussion of the subject it transpired that a number of renters of telephones had been approached, and that they had responded most favourably. The meeting was generally of the opinion that the utilisation of the present telephonic system would be very much cheaper and more effective than any possible development of street alarms.

Indian Telegraphs.—The Administration Report of the Indian Telegraph Department shows that during the last financial year the net additions to the system were 1,791 miles of line, 7,373 miles of wire, and 21 miles of cable. One hundred and sixty-eight new offices have been opened during the year, bringing the number up to 3,103. The accounts show a profit equal to 4·26 per cent. on the capital outlay. During the year some excellent work was done by the department in laying field telegraph lines. The Sikkim line was maintained, as also that in the Chin country. A new line in Assam, a section of the Chin Lushai country, was laid from Jhalnacherra to Fort Aijal, a distance of 59 miles, through a most difficult and unhealthy country. The other two sections of the line through Lushai, from Dimagiri to Fort Tregear and from Pokokko to Haka, were strengthened. The working parties suffered severely from sickness. One hundred and eighty-two miles of extra wire had to be laid to connect Hussan and Abbottabad with the bases of operations at Derband and Oghi, and from those points onwards 103 miles of field wire were laid, and 15 offices opened.

Telegraphic Extensions in Spain.—It is noticeable that while strenuous efforts are being made to induce the various heads of departments to reduce their estimates, with a view to an equilibrium in the Spanish Budget, the telegraph and telephone system is not to be allowed to suffer. According to estimates just drawn up by the Minister of the Interior, we find that it is proposed to create 357 new telegraph stations, and to establish four direct wires, one from Valcarlos to Cadiz, to join with the African cable; another from Barcelona to Bilbao, to join with the English cable; another from Irun to Fuentes de Oñoro, to establish direct communication between France and Portugal; and another between Madrid and Barcelona. A telephone line is also to be established, which will include Seville, Huelva, Cadiz, and Malaga. The Madrid paper, *El Imparcial*, of November 14th last, while expressing satisfaction at this decision, asks the Minister of the Interior and the Director of the Postal Department, why some means cannot be introduced for improving the existing service. "How is it," the paper asks, "that with a fall of a slight shower it becomes necessary to send despatches by post?"

The Indian Telegraph Service.—It is rather disheartening, says the Allahabad *Pioneer*, to be obliged to call attention once more to the case of the officers of the Indian Telegraph Service. But though the grievances of the department, after a prolonged agitation, received recognition at the hands of the Government not so long ago, it would appear that they have not by any means obtained redress. It may be remembered that in 1887 the Secretary of State sanctioned a reorganisation scheme, which was conceived in a liberal spirit, and was intended to settle once for all the grievances under which the service was then labouring. The Government of India, while professing to give effect to this reorganisation scheme, substituted one of their own, which entirely nullified any benefits that were granted to the department by the Secretary of State. At the same time a needlessly vexatious rule was introduced prohibiting officiating promotions from grade to grade. This rule presses very heavily on the department. For example, four senior officers are at present on long furlough, two of whom retire at the expiration of their leave, yet their places cannot under this rule be filled temporarily by officers in the grades below them. The junior officers are thus forced to fill the senior appointments without receiving any extra remuneration for the increased duty and responsibility thrust upon them; and the State thereby effects a considerable saving at the expense of the department. The Viceroy has also been memorialised by officers of the department, but with no better success. The officers of the Telegraph Department now intend to memorialise the Secretary of State on the subject.

The Thunderstorms of 1888-89.—At the meeting of the Royal Meteorological Society on Wednesday, Mr. W. Marriott gave the result of the investigation undertaken by the Society into the thunderstorms of 1888 and 1889. The investigation was originally confined to the south-east of England, but, as this district was found to be too circumscribed, it became necessary to include the whole of England and Wales. In 1888 there were 113 days and in 1889 123 days on which thunderstorms occurred in some part of the country. The number of days with damage by lightning was 33 in 1888 and 38 in 1889; and there were 56 days in each year on which hail accompanied the thunderstorms. The tables of hourly frequency show that thunderstorms are most frequent between noon and 4 p.m., and least frequent between 1 a.m. and 7 a.m. Thunderstorms appear to travel at an average rate of about 18 miles per hour in ill-defined low barometric pressure systems, but at a higher rate in squally conditions. The author is of opinion that individual thunderstorms do not travel more than about 20 miles, and that they take the path of least resistance, and are consequently most frequent on flat and low ground. The author believes that the thunderstorm formations are small atmospheric whirls—in all respects like ordinary cyclones; and that the whirl may vary from one mile to ten miles or more in diameter. There are frequently several whirls near together, or following one another along the same track. The numerous oscillations in the barometric curve are evidently due to the passage of a succession of atmospheric whirls; and it appears that lightning strokes are most frequent when these oscillations are numerous.

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ELECTROMAGNETIC THEORY.—XXI.

BY OLIVER HEAVISIDE.

(Continued from page 111.)

§ 107. Coming next to the products of vectors, it is to be noted at the beginning that the ordinary idea of a product in arithmetic and in scalar algebra does not apply to vectors, because they are not scalars. We cannot, therefore, say beforehand what the product of two vectors ought to be, or determine this question by any prior reasoning of a legitimate nature. We must examine in what way vectors enter into combination as products, and then introduce definitions and conventions of notation to give expression to the facts in the simplest and most convenient way. After this, the work is deductive.

By this examination we are led to recognise two distinct kinds of products of a pair of vectors, the scalar product and the vector product. It is with the former of these that we are now immediately concerned.

We *define* the scalar product of a pair of vectors **A** and **B**, whose tensors are A and B, and whose included angle is θ, to be the scalar AB cos θ, and we denote it by **AB**. Thus

$$\mathbf{AB} = \mathrm{AB}\cos\theta \quad . \quad . \quad . \quad . \quad . \quad (12)$$

defines the scalar product and its notation.

To see its full significance and how it works out, let us first apply (12) to the unit reference vectors, **i**, **j**, **k**, which are coperpendicular, by taking **A** and **B** to be one or other of them in turn. First multiplying each of **i**, **j**, **k** by itself, we get

$$\mathbf{i}^2 = 1, \quad \mathbf{j}^2 = 1, \quad \mathbf{k}^2 = 1, \quad . \quad . \quad . \quad . \quad (13)$$

with the convention borrowed from scalar algebra that **ii** is equivalently denoted by $\mathbf{i}^2$. This may be called the square of **i**. In each of the three cases (13) the vectors multiplied together are of unit length, and are parallel and concurrent, so that the scalar product, according to (12), is unity.

Similarly, the square of any unit vector is unity. And since $\mathbf{A} = \mathrm{A}\mathbf{A}_1$, the square of any vector is the same as the square of its tensor; or

$$\mathbf{A}^2 = \mathrm{A}^2. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Also, the scalar product of any two parallel vectors is the product of their tensors, for $\mathbf{AB} = \mathrm{AB}\,\mathbf{A}_1\mathbf{B}_1$, and $\mathbf{A}_1\mathbf{B}_1$ is now unity.

Next make scalar products of **i**, **j**, **k** in pairs. We get

$$\mathbf{ij} = 0, \quad \mathbf{jk} = 0, \quad \mathbf{ki} = 0. \quad . \quad . \quad . \quad . \quad (15)$$

That is, the scalar product of two perpendicular unit vectors is zero. The same is, of course, true of any two perpendicular vectors. Thus the equation $\mathbf{AB} = 0$ means that **A** is perpendicular to **B**; unless, indeed, one or other of them is zero.

We have also

$$\mathbf{A}_1\mathbf{B}_1 = \cos\theta, \quad . \quad . \quad . \quad . \quad . \quad (16)$$

by dividing (12) by AB; or, the scalar product of any two unit vectors in the cosine of the included angle. This is reckoned positively from concurrent coincidence, so that as θ goes from 0 to 2π, $\mathbf{A}_1\mathbf{B}_1$ goes from 1 through 0 to − 1, and then through 0 again to + 1.

There is, strictly, no occasion to introduce trigonometry. Or we might make the trigonometry be a simultaneously developed subject. It is, in fact, a branch of vectorial algebra, being scalar developments of parts thereof. We may employ the idea of perpendicular projection simply. Thus, we may say that the scalar product of a pair of unit vectors is the length of the projection of either upon the other; and that the scalar product of any vector **A** and a unit vector **i** is the projection of **A** upon the axis of **i**; and, comprehensively, that the scalar product **AB** of any two vectors **A** and **B** is the product of the tensor of either into the projection (perpendicularly) upon it of the other. It is the effective product, so to speak. In physical mathematics scalar products frequently have reference to energy, or activity, or connected quantities. Thus, if **F** be a force and **v** the velocity of its point of application, their scalar product **Fv** is the activity of the force; it is the product of the speed and the effective force. When the force and the velocity are perpendicular, the activity is *nil*, although the velocity may be changing—a fact which familiarity does not render less striking. When **F** and **v** are parallel (whether concurrent or not), **Fv** becomes the same as F*v*, in the common meaning of a product. A notation that harmonises in this way is obviously a convenient one.

Notice, also, that **AB** = **BA**, as in scalar algebra.

A frequently occurring operation is the surface integral of the normal component of a vector; for example, to express the amount of induction through a surface. Here the idea of a unit normal vector **N** is useful. The normal component of **B** is then **NB**, and the integral is Σ**NB**, the summation extending over the surface.

Similarly, to express the line-integral of the effective component of a vector along a line, we may let **T** be the unit element of curve; that is, the unit tangent; then **TE** is the tangential component of the vector **E**, and Σ**TE** is the integral; for example, the voltage between two points along the path to which the summation refers, if **E** be the electric force.

Since **ab** is a scalar, it behaves as a scalar, when considered as a whole. Thus, when multiplied by a scalar, *x*, the result, *x***ab** or **ab***x*, is scalar, being simply *x* times **ab**. When multiplied by a vector the result is a vector; thus, **c.ab** or **ab.c** means **ab** times the vector **c**. The dot here acts rather as a separator than as a sign of multiplication. Thus, to illustrate, **ca.b** means **ca** times the vector **b**; and, similarly, **a.bc** is **bc** times the vector **a**. But, instead of the dot, we may use brackets to indicate the same thing, thus **c.ab** may be written **c**(**ab**). This is, perhaps, preferable in initiatory work, but I think the dot plan is more generally useful.

We have an example of this combination of three vectors in the stress formulæ. Thus, the electric stress vector on the plane, whose unit normal is **N**, is expressed by

$$\mathbf{E.DN} - \mathbf{N}.\tfrac{1}{2}\mathbf{ED}$$

(equation (31), § 72); that is, the sum of two vectors, parallel to **E** the electric force and to **N** respectively, whose tensors are **EDN** and $-\frac{1}{2}$**ED** respectively, where **D** is the displacement. The interpretation as a tension along **E** combined with an equal lateral pressure, obtained by taking **N** parallel to and then perpendicular to **E** or **D**, has been already discussed.

§ 108. As all the preceding is involved in the definition of a scalar product, and is obvious enough, it may be regarded merely as illustrative. The reader might, in fact, say that he knew it all before in one form or another, trigonometrical or geometrical, and that he did not see any particular advantage in the way of stating it in the notation of scalar products. But we now come to a very striking and remarkable property of scalar products, which will go far to justify them as working utilities.

We know that in scalar algebra, when we have a product *xy*, we may express *x* by the sum of any number of other quantities, and similarly as regards *y*, and then obtain the complete product *xy* by adding together all the component products obtained by multiplying every element of *x* into every element of *y*; and that this process may be carried out in any order.

Now, in vector algebra, we know already that there is a partial similarity, viz., that we can decompose a vector **A** into the sum of any number of others, and similarly as regards **B**. The question now is whether the scalar product **AB** is the sum of all the scalar products made up out of the components of **A** paired with the components of **B**, taken in any order. For example, if

$$\mathbf{A} = \mathbf{a} + \mathbf{b},$$

and

$$\mathbf{B} = \mathbf{c} + \mathbf{d},$$

is

$$\left.\begin{aligned}\mathbf{AB} &= (\mathbf{a}+\mathbf{b})\,(\mathbf{c}+\mathbf{d}) \\ &= \mathbf{ac} + \mathbf{ad} + \mathbf{bc} + \mathbf{bd}\,?\end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (17)$$

The answer is Yes, and the process of manipulation is the same as in scalar algebra, that is, as if all the vectors were scalars. Moreover, this property admits of demonstration in a sufficiently simple manner as to enable one to see its truth.

Start with the vector **A**, and first split it up into

$$\mathbf{A} = \mathbf{a} + \mathbf{b} + \mathbf{c}, \quad . \quad . \quad . \quad . \quad (18)$$

two or three vector components being sufficient for illustration. Now project the vector **A** perpendicularly upon any axis, say

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that of **i**. According to our definition of a scalar product, the projection is **Ai**. Now it requires no formal demonstration, but becomes evident as soon as the meaning of the proposition is correctly conceived, that the projection of **A** upon any axis is the same as the sum of the projections of its component vectors, **a**, **b**, **c**, on that axis. That is, the latter projections are either all positive or all negative, and fit together to make up the projection of **A**; or else some may be negative and others positive, when there is overlapping and cancelling, but still with the same result algebraically. This is expressed by

$$\mathbf{Ai} = (\mathbf{a}+\mathbf{b}+\mathbf{c})\mathbf{i} = \mathbf{ai}+\mathbf{bi}+\mathbf{ci}, \quad . \quad . \quad . \quad (19)$$

got by multiplying (18) by **i**.

If we now multiply (19) by any scalar B, so that $B\mathbf{i} = \mathbf{B}$, which is any vector, since **i** may have any direction, we obtain

$$\mathbf{AB} = (\mathbf{a}+\mathbf{b}+\mathbf{c})\mathbf{B} = \mathbf{aB}+\mathbf{bB}+\mathbf{cB}, \quad . \quad . \quad (20)$$

the same as if we multiply (18) by **B** direct.

Similarly, we may split up **B** into the sum of any number of other vectors, say,

$$\mathbf{B} = \mathbf{d}+\mathbf{e}+\mathbf{f} \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

If we substitute this in (20) we have

$$\mathbf{AB} = \mathbf{a}(\mathbf{d}+\mathbf{e}+\mathbf{f})+\mathbf{b}(\mathbf{d}+\mathbf{e}+\mathbf{f})+\mathbf{c}(\mathbf{d}+\mathbf{e}+\mathbf{f}).$$

Now make use of the same reasoning which established (19) and (20), applied to the bracketed vectors, and we establish the property fully, with the result

$$\mathbf{AB} = (\mathbf{a}+\mathbf{b}+\mathbf{c})(\mathbf{d}+\mathbf{e}+\mathbf{f})$$
$$= \mathbf{ad}+\mathbf{ae}+\mathbf{af}+\mathbf{bd}+\mathbf{be}+\mathbf{bf}+\mathbf{cd}+\mathbf{ce}+\mathbf{cf};$$

the expansion being done formally as in scalar algebra in every respect; since the various terms may be written in any order, and each may be reversed, thus, $\mathbf{ad} = \mathbf{da}$.

I have already remarked that a good deal of geometry may be done by the addition property alone. The range of application is greatly extended by the use of the scalar product and the fundamental property (17).

To obtain the Cartesian form of **AB**, put the vectors in terms of **i**, **j**, **k**; thus

$$\mathbf{AB} = (A_1\mathbf{i}+A_2\mathbf{j}+A_3\mathbf{k})(B_1\mathbf{i}+B_2\mathbf{j}+B_3\mathbf{k}). \quad . \quad (22)$$

Now effect the multiplications, remembering (13) and (15). The result is

$$\mathbf{AB} = A_1B_1+A_2B_2+A_3B_3 \quad . \quad . \quad . \quad . \quad (23)$$

For example, the activity of a force is the sum of the activities of its component forces in any three coperpendicular directions. Or, if **A** and **B** are unit vectors, we express the cosine of the angle between them in terms of the products of the direction cosines of the vectors, each product referring to one axis. In (23) we may, if we please, vectorise the six scalars on the right side.

Since the square of a vector is the square of its tensor, we may express the tensor at once in terms of the tensors and the cosines of the angles between a series of vectors into which the original vector is resolved. Thus, for two,

$$(\mathbf{A}+\mathbf{B})^2 = \mathbf{A}^2+2\mathbf{AB}+\mathbf{B}^2, \quad . \quad . \quad . \quad (24)$$
$$(\mathbf{A}-\mathbf{B})^2 = \mathbf{A}^2-2\mathbf{AB}+\mathbf{B}^2; \quad . \quad . \quad . \quad (25)$$

and similarly for three,

$$(\mathbf{A}+\mathbf{B}+\mathbf{C})^2 = \mathbf{A}^2+\mathbf{B}^2+\mathbf{C}^2+2\mathbf{AB}+2\mathbf{BC}+2\mathbf{CA} \quad (26)$$

Here (24) and (25) apply to a parallelogram, and (26) to a parallelepiped. In (24), (25), if **A** and **B** be the vector sides of a parallelogram, then (**A**+**B**) and (**A**−**B**) are the vector diagonals; so (24) gives the length of one diagonal and (25) that of the other.

Adding (24) and (25) we obtain

$$(\mathbf{A}+\mathbf{B})^2+(\mathbf{A}-\mathbf{B})^2 = 2(\mathbf{A}^2+\mathbf{B}^2), \quad . \quad . \quad (27)$$

expressing that the sum of the squares of the diagonals equals the sum of the squares of the four sides. Similarly, by subtraction

$$(\mathbf{A}+\mathbf{B})^2-(\mathbf{A}-\mathbf{B})^2 = 4\mathbf{AB} \quad . \quad . \quad . \quad (28)$$

expressing the difference of the squares of the diagonals as four times the scalar product of two vector sides.

Equation (27) also shows that the sum of the squares of the distances of the ends of any diameter of a sphere from a fixed point is constant. For if **A** is the vector from the fixed point to the sphere's centre, and **B** the vector from the centre to one end of the diameter, then **A**+**B** and **A**−**B** are the vectors from the fixed point to the ends of the diameter. Whence, by (27), the proposition.

There is an application of this in the kinetic theory of gases. For when two elastic spheres collide they keep the sum of their kinetic energies constant. If, then, their velocities before collision be **A**+**B** and **A**−**B**, their velocities after collision are indicated by vectors from the origin (in the velocity diagram) to the ends of some other diameter of the sphere described upon the line joining their original positions (in the velocity diagram) as diameter; which is actually the new diameter depending upon the circumstances of impact.

§ **109**. It is occasionally useful to employ the reciprocal of a vector in elementary vector algebra. We define the reciprocal of a vector **a** to be a vector having the same direction as **a**, and whose tensor is the reciprocal of that of **a**. We may denote the reciprocal of **a** by $\mathbf{a}^{-1}$ or $1/\mathbf{a}$. Thus as $\mathbf{a} = a\mathbf{a}_1$, we have

$$\mathbf{a}^{-1} = \frac{1}{\mathbf{a}} = \frac{1}{a\mathbf{a}_1} = \frac{\mathbf{a}_1}{a} \quad . \quad . \quad . \quad . \quad . \quad . \quad (29)$$

Any unit vector is, therefore, its own reciprocal.

The reciprocal of a vector, being a vector, makes scalar products with other vectors. Thus $\mathbf{ab}^{-1}$ or $\mathbf{a}\,\mathbf{b}$ means the scalar product of **a** and $\mathbf{b}^{-1}$, and we therefore have

$$\frac{\mathbf{a}}{\mathbf{b}} = \mathbf{ab}^{-1} = \frac{a\mathbf{a}_1}{b\mathbf{b}_1} = \frac{a}{b}\mathbf{a}_1\mathbf{b}_1 = \frac{\mathbf{ab}}{b^2} \quad . \quad . \quad . \quad (30)$$

The tensor of $\mathbf{a}\,\mathbf{b}$ is $(a\,b)\cos\theta$, where θ is the angle between **a** and **b**, or between their reciprocals, or between either and the reciprocal of the other.

So $\mathbf{a}\,\mathbf{a}$ or $\mathbf{aa}^{-1}$ or $\mathbf{a}^{-1}\mathbf{a}$ equals unity.

In using reciprocals the defined meaning should be attended to, especially when put in the fractional form. Thus we easily see that $\mathbf{ab}^{-1} = \mathbf{a}\,b^2$, because the tensor of **b** is b^2 times the tensor of $\mathbf{b}^{-1}$. But we cannot equivalently write $a^2/\mathbf{ab}$, because this is $(a\,b)/\cos\theta$, which is quite a different thing.

Notice that $\mathbf{a}^{-1}\,\mathbf{b}^{-1}$ is not the same as $(\mathbf{ab})^{-1}$. The first is $a^{-1}b^{-1}\cos\theta$, whilst the latter is $a^{-1}b^{-1}\cos\theta$.

§ **110**. We know that in the equation

$$\mathbf{r} = x\mathbf{i}+y\mathbf{j}+z\mathbf{k},$$

where **r** is the vector distance of a point from the origin, the scalars are the lengths of the projections of **r** upon the axis. How should we, however, find them in terms of **r** algebraically? To find x we must operate on the equation in such a manner as to cause the **j** and **k** terms to disappear. Now this we can do by multiplying by **i**. For **i** is perpendicular to **j** and **k**, so that multiplication by **i** gives

$$\mathbf{ri} = x\mathbf{i}^2 = x.$$

Similarly, $\mathbf{rj} = y$ and $\mathbf{rk} = z$.

From this obvious case we can conclude what to do when the reference vectors are not perpendicular; for instance, in

$$\mathbf{r} = f\mathbf{a}+g\mathbf{b}+h\mathbf{c}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (31)$$

where **a**, **b**, **c** are any independent vectors. To find f we must multiply by a vector perpendicular to **b** and **c**, say **l**, so that $\mathbf{lb} = 0$, and $\mathbf{lc} = 0$. Then

$$\mathbf{rl} = f\mathbf{al}, \quad \text{therefore} \quad f = \mathbf{rl}/\mathbf{al}.$$

Similarly to isolate g and h, so that we get

$$\mathbf{r} = \frac{\mathbf{rl}}{\mathbf{al}}\mathbf{a}+\frac{\mathbf{rm}}{\mathbf{bm}}\mathbf{b}+\frac{\mathbf{rn}}{\mathbf{cn}}\mathbf{c}, \quad . \quad . \quad . \quad . \quad (32)$$

where **l**, **m**, **n** are vectors normal to the three planes of **b**,**c**, **c**,**a** and **a**,**b**. This exhibits explicitly the expansion of any vector in terms of any three independent vectors **a**, **b**, **c**, as the three edges of a skew parallelepiped. This case, of course, reduces to the preceding Cartesian case by taking **a**, **b**, **c** to be **i**, **j**, **k**, when **l**, **m**, **n** will also be **i**, **j**, **k**, or any scalar multiples of the same.

Observe the peculiarity that auxiliary vectors are used, each of which is perpendicular to two others, that is, to the plane containing them. These auxiliary vectors bring us to the study of the vector product.

(To be continued.)

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THE EDUCATION OF THE ENGLISH ENGINEER.

The admirable little volume on "Engineering Education in the British Dominions," which has just been issued by the Council of the Institution of Civil Engineers, must be a source of lively satisfaction to those who, but a few years ago, had reason to fear for the pre-eminence of the "English engineer." In the sixties, when the appearance of the "techniker" and his success in many branches of engineering first began to attract attention in this country, we were enjoying to the fullest extent a system of engineering education peculiarly English in its utter lack of system. In November, 1868, in his inaugural address at the Edinburgh University, Prof. Fleeming Jenkin, describing the state of things which then existed in England, said, "Etiquette requires the engineer to show a certain reluctance to receive the pupil; and, in fact, the ordinary pupil is a sort of nuisance in an office, only tolerated in consideration of the fee which accompanies him. From personal experience I can declare that most pupils are so ignorant of algebra that they are not only incapable of working out a result for themselves, but actually cannot apply the simple formulæ which are given in engineers' pocket-books. The calculation of the solid contents of a wall is often beyond their powers. Their arithmetic is very shaky; and a knowledge of physics, chemistry, geology, or the higher mathematics, is wonderfully rare. . . No one teaches them anything, but they have the opportunity of seeing how some actual work is done; they see just how much mathematics is absolutely required, and they pick it up. . . The one point for them is to convince their masters that they are useful; and hence, notwithstanding their ignorance at starting, the neglect in which they are left during their pupilage, the absence of opportunities for improving their theoretical acquirements, many of them do become useful men. . . . But our success costs a vast expenditure of money and of brain, which could be turned to better purpose if we knew how to calculate the results to be expected from a given combination with some certainty beforehand. And not only does our ignorance cause much wealth to be wasted by the community on useless trials, but it prevents the trial of many new schemes, because the engineers or managers to whom they are submitted feel that they have no means of judging beforehand of the probability of success; so they, wisely in their generation, think they had better stick to the old plans, and in nine cases out of ten they are right; but the rejection of the tenth case is a dead loss to themselves and to the country." Such was the burden, not only of a "professor's" inaugural address, but of the many other similar addresses delivered at that period by "practical" men like Sir John Fowler and Mr. Thomas Hawksley. General Chesney, in reporting to the India Office on this subject, was even more emphatic. "The present mode of training an engineer, where a young man pays a fee to a civil or mechanical engineer for permission to work in an office or workshop, and pick up such crumbs of knowledge as fall in his way," said General Chesney, "is *not* education; and the cases must be very rare where persons, after undergoing such a training, will be found to pass an examination involving any knowledge of the principles of mathematics or theoretical mechanics. They usually take no knowledge of that subject into the office, and gain none there."

The great defect of the old system was *waste*. The pupil came to the workshop ignorant, and even with the best will in the world consequently wasted much time in slowly acquiring by "trial and error," and painful poring over pocket-books and the like, the elemental facts of his trade. No one taught him anything; and the same false start continued to act as an effective drag long after the shops had been left behind. Confronted by an entirely new set of conditions the majority of these self-taught engineers would have been found wanting, unable to "predetermine the characteristic" of the new development. Hence much waste of time, money, and brain tissue —a waste, be it remembered, affecting not only the individual himself but the country at large. There is, however, compensation in all things; and in a commercial community a method which results in waste of those two precious commodities, time and money, stands self-condemned. Fortunately, moreover, the cause of engineering education possessed able advocates at the very moment when the time was ripe for its advocacy, and, still more fortunately, it was a comparatively easy task to demonstrate to conviction to the business mind that, apart from national and individual interests, it was a question of pounds, shillings, and pence. Thus it has come about that while it is only some five-and-twenty years ago since the Indian Government made the discovery that engineers were not "brought up" but "dragged up" in this country, there is now some danger of over-educating. Almost within the last decade colleges for instructing engineers, civil, mechanical, mining, electrical, and chemical, have sprung up, and the institutions which previously possessed engineering courses have enlarged their scope and revolutionised their methods.

The old system of undiluted apprenticeship was peculiarly in consonance with the English way of looking at things. It had, moreover, all the force of a time-honoured and lucrative custom. That it should have collapsed so completely must be taken as a tribute to the logic of facts and the eloquence of sundry professors and eminent "practicians." Britons have always had a fondness for roughing it, or, rather, for making others rough it; and the process is undeniably a healthy one in its way. If the omniscience and proneness to mathematical formulæ said to be characteristic of the typical "techniker" survive a due course of "roughing it," these vices may be considered as inherent to the species. One apparently powerful argument in favour of the old method of evolving an engineer was that it turned out good men. Granting with all readiness that such was indeed the case, it might well have been asked whether still better results were not to be anticipated from a more enlightened system. A man who, in spite of all the hindrances which formerly existed, managed to attain a thorough grip of the theory and practice of engineering must indeed have been superior to the *average* man of that or any other day. Be the philosophical dictum that a great nation exists for the sole purpose of producing great men as true as it may, it is somewhat difficult to see where the advantage of erecting *artificial* obstacles to their production came in. The great engineers who succeeded in overcoming these artificial obstacles were necessarily giants of the first order of magnitude; but with fewer barriers we might have had more engineers of abnormal intellectual stature. Moreover, giants can take care of themselves; they come to the top in any case; and, with all deference to the aforesaid philosophical dictum, it is permissible to hazard the opinion that it is the *average* man who wants to be looked after. That the old order of things was favourable to the average man no one seriously contended.

When the advocates of technical training first began to make their voices heard in the land they were not unnaturally accused of wishing to manufacture engineers in college laboratories. Whether or no some such idea may not have lurked in the brains of a few ardent professors it is not now worth while to inquire, since the hastiest perusal of the remarks to be found at the head of the syllabuses of the various engineering colleges will show exactly what the object of college instruction is considered to be. At University College (London) it is understood that no college work "can render unnecessary a pupilage, or its equivalent, in the actual practice of the profession. . . . But the training given in the college will be found to be of value, not only directly, but also by enabling those who have gone through it to take fuller advantage of the opportunities afforded during a professional pupilage." At Cambridge, "although the workshops have been arranged on a considerable scale, the use of them is by no means intended to take the place of pupilage in a larger establishment." At the Mason Science College, Birmingham, "the whole of the teaching in the classes is practical and technical in its aim, no theory being introduced except such as has a direct bearing on the problems of professional practice, and no theories being taught until the facts upon which they are based have been fully explained." At Glasgow University we are told that "the work of the classes is not intended in any way to supersede the usual requirement of pupilage or apprenticeship in engineering;" and that "in drawing up the course the University have had in view to avoid altogether any competition with the offices of civil engineers or the workshops of mechanical engineers. . . ." In the United Kingdom, therefore, we are, it seems, all agreed

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as to the futility of endeavouring to make engineers at college.

With such unanimity as regards the object to be aimed at it is not surprising to find that the curricula of our more important engineering training centres are very similar. They are, however, sufficiently diversified to ensure individuality. Nothing could be more detrimental to healthy and sustained progress than a crystallisation of methods. May no professional or engineering Confucius arise with a system of education so perfect as to render its universal adoption a mere matter of time!

As a specimen engineering curriculum, that of University College (London) may be taken. Here the complete course extends over three years, and comprises—

First Year.

Mathematics, Junior.	Experimental Physics.
Graphics, Junior.	Graphics, Drawing.
Mechanics.	Economic Geology.
Surveying.	

Second Year.

Engineering, Junior.	Graphics, Senior.
Machine Design and Drawing, Junior.	Practical Physics.
	Electrical Technology.
Mathematics, Senior.	Chemistry.

Third Year.

Engineering, Senior.	Mathematics, Senior.
Machine Design and Drawing, Senior.	Physics, Senior.
	Civil Engineering or Electrical Technology.
Engineering Laboratory.	

There is an unrestricted admission of students, many of whom only stay two years, and in some instance a year of apprenticeship is taken between the two years of college work, the remainder of the apprenticeship coming after the second year.

Provided an engineering student comes to college properly equipped, mentally and educationally, two years should suffice to further equip him with the scientific and practical knowledge necessary to enable him to make the most of the period of pupilage and the most of his subsequent opportunities. Those who can afford the time will not do amiss to prolong the college period, but except in special cases a three years' course is somewhat of a luxury. The sandwiching of a year of apprenticeship between two years of college life does not seem *primâ facie* likely to work well in practice, but rather to prove a disturbing element just at a period when the majority of us require to take a little ballast aboard. All paper examinations, whether competitive or qualifying, are to be regarded as necessary evils, to be borne with cheerful resignation in the hope that at some future eon in the history of the development of man something more to the point may be devised. But until that happy day arrives we should endeavour to weed out the "duffers" somehow, if only in the interests of the better qualified; and it would seem advisable and possible to adopt some golden mean between setting brain-racking entrance examination papers and allowing an unrestricted admission of students.

At King's College the course of mechanical engineering extends over three years, and there is no entrance examination. At the Central Institution the first year's course is the same for all, and the student then specialises electing to join the engineering, the physical or the chemical department, with a view of being educated as a civil or mechanical engineer, an electrical engineer or a chemical engineer; but studies in all four departments continue during the second year. Students who desire to go through a complete course and to take the diploma of the Institute have to pass an entrance examination. Besides the regular matriculated students those who have adequate knowledge are admitted when there is room to any courses they may select, and are allowed to work in the laboratories—an arrangement which would appear to solve the difficulty with which every popular institution with limited class-rooms and laboratories is sooner or later confronted, namely, how to prevent overcrowding without perchance weeding out a large percentage of admirable embryo engineers. At Finsbury Technical College the course extends over two years only, though students may remain longer.

The Royal Indian Engineering College at Cooper's Hill possesses peculiar interest to "educationalists," since it owes its existence to the fact that less than a generation ago the scientific training of engineers was such a comparatively unknown art in this country that the Indian Government, in despair of obtaining an adequate supply of suitable men by any means less heroic, undertook the education of its own engineers. From 1871 to 1883 the Cooper's Hill courses had reference solely to Indian engineering; at the present day the college opens its doors to all who can pay its fees, and the curriculum has been altered so as to make it attractive to students willing to look for a professional career elsewhere than in India.

At University College, Liverpool, the engineering course has a decidedly "civil" turn; and, as at Bristol, arrangements are made to permit of students entering some engineering works during the summer. At the Yorkshire College, Leeds, the distinguishing feature is that equal importance is attached to training for the scientific professions and to preparation for university degrees.

As a fitting conclusion to this *résumé* there will be found below a list of the colleges in the United Kingdom which are mentioned in the volume to which we have been alluding. It will be seen that there are no less than 33 colleges in the Kingdom where systematic instruction is given in the elements of the art of engineering, and that of these at least 16, or nearly 50 per cent., are new creations since 1870, the year in which the Council of the Institution of Civil Engineers issued their pamphlet on "The Education and Status of Civil Engineers in the United Kingdom and in Foreign Countries." It cannot be deemed other than satisfactory that such a number of centres of engineering education should now exist, that so many should have sprung up in response to the demand for scientific training; and that the governing bodies of these institutions should have so clear and so correct a conception of the scope and of the limitations of technical education as it affects the engineer. No doubt much remains to be done, but a vigorous and encouraging start has been made.

ENGINEERING EDUCATIONAL INSTITUTIONS IN THE UNITED KINGDOM.

1. University College (London).
2. King's College (London).
3. Royal College of Science and School of Mines.
4. Central Institution (1884).
5. Finsbury Technical College (1883).
6. Cooper's Hill College (1871).
7. Royal Naval College (Greenwich).
8. Crystal Palace School of Practical Engineering (1872).
9. Millard Laboratory (Oxford) (1886).
10. Department of Engineering (Cambridge).
11. Owens College (Manchester).
12. Manchester Technical School.
13. University College (Liverpool) (1882).
14. Yorkshire College (Leeds) (1873).
15. Bradford Technical College.
16. Durham College of Science (Newcastle).
17. Mason Science College (Birmingham) (1880)
18. University College (Bristol) (1876).
19. University College (Nottingham) (1881).
20. Firth College (Sheffield) (1879).
21. Sheffield Technical College (1880).
22. Hartley Institution (Southampton).
23. University College of South Wales (1882).
24. University of Glasgow.
25. University of Edinburgh.
26. Heriot-Watt College (Edinburgh) (1886).
27. Glasgow and West of Scotland Technical College (1886).
28. University College (Dundee) (1882).
29. Trinity College (Dublin).
30. Royal College of Science (Dublin).
31. Queen's College (Cork).
32. Queen's College (Belfast).
33. Queen's College (Galway).

THE COMBINED RESISTANCE OF CONDUCTORS IN PARALLEL.

The formula for finding the combined resistance of two or more conductors in parallel is well known to every student, and a very clumsy formula it is; so clumsy, in fact, that it is generally customary to treat of conductivities, and then translate back into resistances. The feeders which are laid by supply companies in the streets offer an instance of combined resistance, since they are made up, in many cases, of strips of copper side by side. If it is desired to put down a feeder of a

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certain given resistance, making use of the standard size of copper strip, it will be necessary to calculate how many strips will be required; and since it is improbable that a whole number will make up the exact amount, the required resistance must be adjusted by using a short piece. To calculate the length of these by the ordinary formula is easy enough, but the following geometrical construction is very much more easy, and will give results quite accurate enough for practical purposes. On any convenient scale draw A B, representing the length of

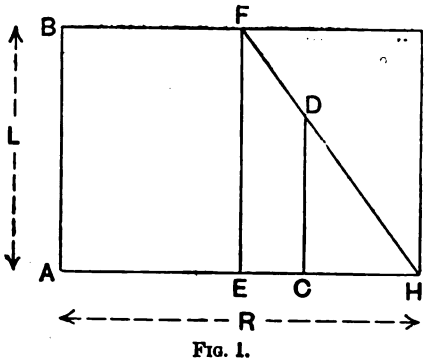


Fig. 1.

the feeder, and on any other convenient scale let A H represent the resistance of one strip. Let the required resistance be represented on this scale by A C. To find the additional length of conductor to be run in parallel in order to bring down the resistance from A H to A C, bisect A H at E, and draw E F perpendicular to A H, making E F equal to A B. Join F H from C, draw C D perpendicular to A H, cutting F H at D. C D will be the length required, and the combined resistance of A B and C D will be A C.

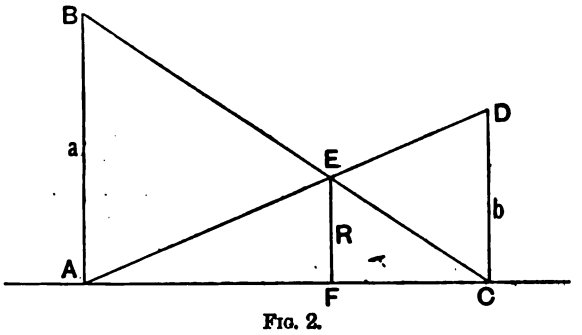


Fig. 2.

The two following constructions appeared in *Le Génie Civil*, May 2, 1891, p. 12:—"It is well known that the combination of several resistances in parallel is the reciprocal of the resistance of each circuit, and we will endeavour to describe a simple and rapid method of finding the combined resistance of a number of circuits, which was pointed out some little time back by the *Elektrotechnische Zeitschrift*.

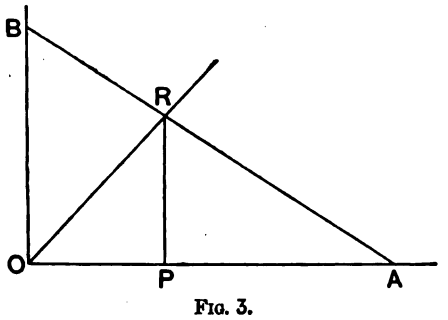


Fig. 3.

"Let a and b be the two resistances connected in parallel of which we wish to determine the combined resistance. Take two points, A and C, in a horizontal line, A C, and from A and C erect two perpendiculars, A B, C D, representing to any convenient scale the resistances a and b. Join B C and A D. From the point E where these two lines meet, let fall the perpendicular E F on the base A C. Then the line E F will represent the combined resistance r, of the two resistances a and b. The value of r may also be found by the well-known algebraical expression

$$r = \frac{a\,b}{a+b}.$$

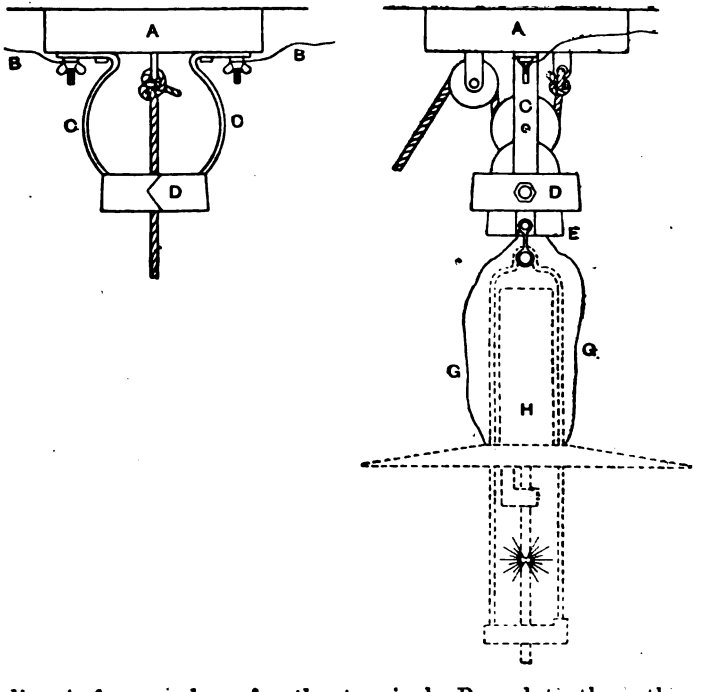
"If there are more than two circuits we can then proceed to take the value r and the third resistance, and repeat the same operation as before, and so on, until the circuits are exhausted."

In *Le Génie Civil*, Sept. 22, 1891, p. 362, the following method is pointed out:—"Let O B and O A be drawn at right angles to each other, and let O R bisect the angle A O B. To any suitable scale measure off O B and O A as representing the resistance in shunt. Join A B, cutting O R at R. From R let fall R P perpendicular to O A. Then R P shall be the resultant resistance required. This is easily seen, since the angle A O R being 45deg., R P = O P and

$$\frac{1}{RP} = \frac{1}{OP} = \frac{1}{OA} + \frac{1}{OB}."$$

AUTOMATIC SWITCH FOR SUSPENDED ARC LAMPS.

A switch for placing an arc lamp in circuit by the act of hoisting it has been designed by Messrs. Wagg and Hudson, and has been extensively used at Woolwich Arsenal. A wooden



disc, A, forms a base for the terminals, B, and to these the leads are attached. Springs, C C, hold a divided ring, D. A conical wooden plug, E, is fixed to the pulley which supports the lamp, and on the surface of this plug metal strips are fastened. The wires G connect these with the terminals of the lamp. When the lamp is raised, the conical plug opens the half rings, and completes the circuit through the lamp. On lowering for trimming, the rings close and maintain the circuit. Modifications of this arrangement allow wire rope to be used, and for parallel working the rings are arranged so that they do not close when the lamp is lowered.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, December 18th.

PHYSICAL SOCIETY.

5 p.m. Ordinary Meeting. Paper to be read: "On Interference with Alternating Currents." By H. Kilgour.

JUNIOR ENGINEERING SOCIETY.

8 p.m. Ordinary Meeting. Paper to be read: "Engineering Practice in the Cleveland and North-East Coast Districts. By S. H. Wells, Wh.Sc., Stud. Inst. C.E.

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SPECIAL NOTICE.

In **Christmas Week** "The Electrician" *will be* **Published** *on* **Thursday**, *instead of on Friday. Contributions intended for our issue of the 25th inst. must therefore reach the Office not later than Wednesday morning's post.*

Advertisers *will also please note.*

DOES ELECTRICITY EXIST?

Discussions on the exact nature of electricity are too often to be deprecated as being mere waste of time, temper and brain tissue. Our premises are as yet too shaky to permit of the building up of a solid superstructure of logical deductions; even the giants soon get out of their depth, while the rank and file flounder from the commencement. These remarks have, however, only a strictly local application. Across the Atlantic a determination of the exact nature of that which we call electricity would probably make an appreciable difference in the net profits of many an electricity supply company. If electricity is a manufactured article, the State tax-gatherer will in most cases deal tenderly with central lighting stations. But before this happy consummation can be attained, the law must decide, firstly, whether or not electricity is a form of energy, and if so whether transformation of energy constitutes a manufacture; secondly, whether or not electricity is a substance, and if so whether it can be held to be manufactured at the generating centre.

While not presuming for a moment to offer any material assistance in settling this delicate question, we venture to make one or two observations on the subject *apropos* of the interesting series of articles which is commenced by Mr. H. E. Harrison

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in our present issue. We have requested Mr. HARRISON to place before our readers a brief and elementary account of the principles underlying the measurement of alternating currents, with special reference to the effect of choking coils on the apparent current, and the effect of an inductive circuit on ordinary electric meters. Mr. HARRISON takes his stand with a redoubtable ally when he sides with Dr. OLIVER LODGE, to whose "Modern Views of Electricity" he alludes. So imbued has electrical science become with analogies, that we often forget whether the trains of geared wheels which are so ingeniously and satisfactorily used to explain electrical phenomena are a pure analogy, a working hypothesis, or an attempt to explain an actual mechanism which may be assumed to exist on a subtle and infinitesimal scale. Dr. LODGE has held at different times, or now holds when in different moods, or uses on different occasions, two theories which appear to us to be distinct. In one of these, particles of ether—whether atomic, or molecular, or vortical, matters not—are geared together; and electrical phenomena are lucidly explained by the relative motions, transmissions of motions, shear and slip of these particles. In the other, electricity is treated as a substance, having perhaps a molecular structure. Both of these theories are alluded to in the opening paragraphs of Mr. HARRISON'S article; and, strictly for the purpose of clearly explaining the nature of a current, he adopts the stream of particles as a suitable hypothesis. When students are thus clearly warned that the language of hypothesis is being used, no exception can be taken to the expression "quantities of electricity." The definition of a coulomb naturally follows, and Mr. HARRISON seizes on the idea to express in most forcible and unmistakable terms the difference between quantity and current. It is, therefore, with no intention of criticising the accuracy of his language that we question whether in a more general and scientific sense the idea of a coulomb is necessary, and whether the existence of a substance called electricity is tenable.

There was a time when heat was with little or no hesitation pronounced to be a substance. We have heard that somebody holds that the undulatory theory of light is tottering, and must shortly fall ignominiously. A public lecture was given not long ago to prove that sound is due to the emission of small particles, and that the modern theories of acoustics are completely illusory; but no one, to our knowledge, teaches that heat is a "thing." Metaphysics are excluded from our columns for obvious reasons, and there is no occasion to discuss the idealistic and materialistic philosophies. An American thinker has defined "a thing" as "is-ness," and "matter" as "is-ness possessed of some-whatness." That is quite sufficient for our purpose. Though heat is not matter it is a mode of motion of something, and this may be matter or ether according as we consider the heat in a body or radiant heat. We can draw no line between radiant heat and light, and there is no line between light and electro-magnetic disturbances. There seems, then, to be no reason why we should, when speaking scientifically, say that electricity is ether, since we do not say that sound is air. If it be conceded that electrical phenomena are due to motions of or strains in ether, why should electricity be considered as a substance when it is readily accepted that sound is mere motion? This being so, what becomes of the coulomb? In another column we allude to several traditions which were created by the electrician and have been unconsciously adopted by the electrical engineer, who invests them with an unreal value, and who should now cast them aside. The coulomb likewise seems to be an ancient residuum of the fluid theories of electricity which have been abandoned by an overwhelming majority, though perhaps not by all students of electrical science. Taking an excellent illustration, which Mr. HARRISON will give in the course of his articles, namely, the passage of visitors through a turnstile; when a hundred persons have passed, they can be collected, counted, and seen; they exist. When a coulomb has passed through a voltameter, where is it? What we really find is a result of the passage of a certain number of amperes during a certain period of time. The grammes of silver are not coulombs any more than the mud on a door-mat can be said to be a crowd because it has been caused by the passage of a number of people. If, in our metaphorical or hypothetical language we wish to clearly express a current, we are forced to say that it is as though something flows. How much of that thing flows? and how do you measure how much? The coulomb naturally presents itself; and for the purpose of concentrating the thoughts of a student it serves a very useful purpose. A thermal unit of heat is a much more important idea than a coulomb, because there is no word for a thermal current. The rate of transfer of heat is an everyday matter of calculation, and the processes are as simple as possible; but some ill chance might have suggested a thermal current, and temperature might have been called thermo-motive force. Fortunately, the paths of heat are not so tortuous as those of electric currents, and the transfer is rarely by any other than a fairly straight route.

The relations which HERTZ and others have indicated between electrostatic and electromagnetic disturbances introduce some difficulties into the otherwise simple considerations of pure static electrification and simple magnetism; and from the point of view of mental imagery, it seems more easy to conceive that every molecule is a minute magnet than to contemplate the Amperian hypothesis that magnetism is due to the circulation of molecular electric currents. If it be granted that every molecule is a magnet, it is only necessary to move it in order to produce both electromagnetic and electrostatic phenomena. In fact, it is a general law that the continuous motion of magnetic lines produces electrostatic force, *i.e.*, electromotive force. This is proved by arranging a conductor along the lines of electrostatic force, since a current is produced in the wire directly the circuit is closed. The only reason why such currents are not observed in ordinary electrostatics is because the mere introduction of the conductor into the electric field entirely alters the condition of the latter, since, as a rule, the energy involved in electrostatic effects is infinitesimally small. Theory indicates that if the wires used were sufficiently thin, and the instruments delicate enough, electrostatic phenomena could be investigated by electromagnetic instruments; and we can consider electrostatic effects as primarily due to the motion of lines of magnetic force due, say, to molecular magnets. Why, then, do we need the idea of something called electricity? This point of view is perceptibly strengthened by the remarkable investigation which has been recently made at the Royal Institution, whence the spirit of Discovery seemed to have fled, giving place to Discourse. The behaviour of liquefied oxygen in a spheroidal state was remarkable enough; only a year or two ago a speaker at the Institution of Civil Engineers raised a titter when he said that under intense pressure, liquefied gas could be seen in drops or jets on the walls of a coal mine; and the pouring of liquid oxygen from one tumbler to another seemed almost equally incredible. The experiment was wonderful, but was of little or no scientific value. But now the liquid gas, placed in a crystal dish, and held beneath the poles of FARADAY'S historical electro-magnet, was raised in a mass, and hung to the

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metal like a handful of iron filings. FARADAY showed that oxygen was magnetic, and the loss of magnetism when iron is heated is well known; but such a result as that which Prof. DEWAR described to the Royal Society last week is a startling one. Indirectly at first sight, but perhaps closely connected with this, is the suggestion of Prof. HOUSTON that the actinic action of light is a species of electrolysis. The decomposition of carbon dioxide by chlorophyll in a living leaf under the influence of light, the absorption of carbon, and the setting free of oxygen may be an electrolytic action, and seems to be accompanied or determined by a minute difference of potential. It is more easy to imagine that chemical affinity and magnetic attraction are identical than that they are two distinct forces. Magnetism may lurk in unsuspected materials and in unknown conditions. But magnetism does not "exist"; it would appear to be the property of a molecule, whereby a strain is set up in the neighbouring ether. If this is so, leaving THALES and his amber, the innermost recesses of electrical science should be studied from the electromagnetic point of view; and whether electrostatics can be successfully attacked from that quarter or no, the idea that electricity is a substance, and that we can have lumps of it measured in coulombs, will probably vanish without a regret.

THE PRINCIPLES OF ALTERNATE CURRENT MEASUREMENT.

BY HUGH ERAT HARRISON, B.SC.

Introductory.

The measurement of electrical quantities seems to cause great perplexity to many young electricians, and especially to those who have received no scientific training outside their special subject.

The older fluid theories having proved altogether insufficient, and the true nature of electricity being still undetermined, the writers of text books and teachers frequently abandon all reference to such theories, even to the extent of not using the useful analogies which at least are suggested by them. An attempt is made to teach *what electricity does*, without any reference to *what electricity is*. The abstract is mistaken for the concrete, and confused ideas are the natural result.

It is generally extremely difficult to describe anything new without using, in a metaphorical sense, the name of something which resembles it in some of its chief properties. The retention of such words as "current," "pressure," and others, at all events, indicates an analogy, however carefully any special reference to it may be avoided.

No book has been published, for some years past at all events, which has done so much to help the student to a clear conception of his subject as Dr. Lodge's "Modern Views of Electricity." The portion of the volume which treats of electricity in motion explains at length a working hypothesis of the nature of electricity, and shows how many electrical phenomena may be accounted for. The hypothesis is, perhaps, very far from the truth; but it gives the reader a mental image of what may be happening, and is, therefore, a most valuable aid to memory.

Electricity is assumed to be the luminiferous ether, or rather electrical effects are assumed to be produced by ether in certain conditions. Ether pervades everything, interstellar space and matter alike. It is incompressible, though capable of distortion, and its properties are modified by the presence of different kinds of matter. The particles of ether, to use an easily understood expression, are geared together in some way, so that in space or within insulating material one particle cannot move past another, though it may rotate; but the presence of a conductor so alters the state of these particles that they may move about among themselves in much the same way as particles of water do. A current of electricity through a conductor is assumed to be a stream of these particles. This is not the only hypothesis made as to the nature of an electric current, but it is adopted here as the one most suitable for the present purpose of considering certain points in connection with the measurement of some electrical quantities and the units and standards employed.

The Coulomb, the Ampere.

If an electric current is flowing round a circuit, A B (Fig. 1), the quantity of electricity in motion is unknown, the actual velocity with which the ether particles or the electricity passes through any section, S, of the conductor is also unknown. The speed may be thousands of miles per second, or it may be but the fraction of an inch per hour. One thing, however, is clear; if the current remain constant, twice the quantity of electricity will be carried across S in two seconds that will be carried in one. Whether the speed of the current is so great that the same individual particles are carried round the circuit

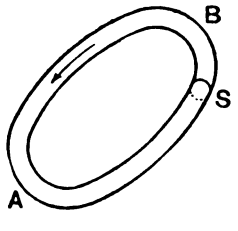

FIG. 1.

many millions of times in a second, or so small that hours elapse before a particle again crosses, matters nothing. The same identical quantity passing six times is considered the same thing as six times the quantity passing once.

Two quantities of electricity can be compared by chemical means. If quantities can be compared, a unit or standard by which all other quantities of the same thing shall be measured can always be selected.

Let a portion of the solid conductor A B, Fig. 1, be replaced by a solution of nitrate of silver in water, L, Fig. 2; if the direction of the current is that indicated by the arrows, silver will be deposited on the surface M N, by which the electricity leaves the liquid and re-enters the solid; to keep the strength of the solution constant during an experiment, the surface P Q must be made of silver, when metal will be found to be carried *into* at the same rate as it is caried *out of* the solution.*

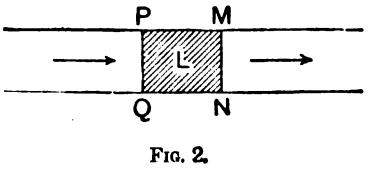

FIG. 2.

The weight of silver deposited is proportional to the quantity of electricity which crosses the surface M N, and the practical unit of quantity is called the coulomb.

A coulomb may be defined as that quantity of electricity the passage of which deposits 0·001118 gramme of silver on the surface M N.

Having fixed upon the *unit quantity of electricity*, or coulomb it is easy to get the *unit of current*, or ampere; but as confusion is frequently caused by an indiscriminate use of the names of these totally different units, the distinction between them must be emphasised, and the inevitable parallel drawn between water and electricity.

A pound of water is a perfectly definite quantity, and may be taken as *unit quantity of water*. If, however, a stream of water is flowing in a conduit and a measure of the current is required, a new unit must be introduced. Clearly the current cannot be measured in pounds only, for the conduit may contain exactly as many pounds of water whether it is flowing in a current or is at rest. The magnitude of the current is

* For the method of using the silver voltameter, see *The Electrician*, Vol. XXVII., p. 325.

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measured by the quantity which flows; and *unit current of water* may be defined as a flow of one pound per second. The point to be specially noted is this: a current of water cannot be measured by the single unit of quantity, the pound. The unit is a compound one, and involves the *unit of time* as well as the *unit of quantity*.

"A current of ten pounds" affords no clue to the magnitude of the current, but "a current of ten pounds per second" gives a perfectly definite measure of the current as already explained.

Mutatis mutandis, what has been said for water applies equally to electricity.

The coulomb is a definite quantity of electricity; but a current of electricity cannot be measured in coulombs alone, for the same reason that a current of water cannot be measured in pounds alone. But, if the current flowing (Fig. 2) has to be measured, this can be done by finding out how many coulombs flow across the section S in one second; the measurement of the rate at which the coulombs pass is actually made by the chemical means indicated in Fig. 2.

For commercial purposes the Board of Trade says, "That an unvarying current which, when passed through a solution of nitrate of silver in water, in accordance with the specification attached to this report, deposits silver at the rate of 0·001118 of a gramme per second, may be taken as a current of one ampere."

This definition is, in effect, primarily a definition of the "coulomb" from which is immediately deduced the definition of the "ampere," although the Board of Trade neither specifically defines nor, indeed, ever uses the word coulomb.

"Quantity of current" is an expression frequently used by working electricians sometimes in the sense "strength of current," at other times to mean "quantity of electricity." The latter use probably arises from the fact that the discharge from a secondary battery may be measured in "ampere hours;" an ampere hour, meaning the quantity of electricity delivered by a current of one ampere flowing for one hour, is the same thing as 3,600 coulombs, and is, of course, quite a different thing from the ampere, which denotes the rate at which electricity is being delivered.

When, however, the meaning of an expression is ambiguous its use should be most carefully avoided.

The Alternating-Current Ampere.

If the ever-varying value of the electromotive force set up in the armature of an alternating-current dynamo machine, whose armature coils are not wound on iron cores, be plotted in the form of a curve, E (Fig. 3), of which the abscissæ represent

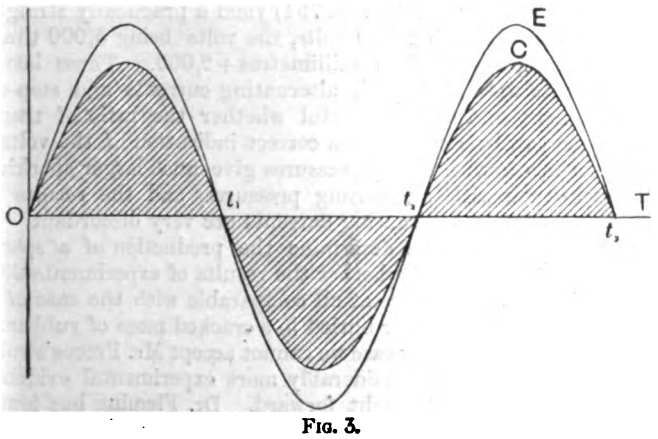

Fig. 3.

intervals of time and the ordinates the corresponding value of the electromotive force, it will be found that such a curve does not differ appreciably from a curve of sines. One direction along the conductors being arbitrarily considered positive the ordinate representing an electromotive force acting in that direction is considered positive and drawn above O T; but an electromotive force acting in the opposite direction is considered negative, and its ordinate drawn below O T, the same convention is also adopted to show the direction in which a current flows along the conductor.

Suppose the terminals of the machine to be joined through some non-inductive circuit of resistance R, then the curve C representing the current at any instant, both in magnitude and direction, can be drawn by multiplying the E.M.F. ordinates by 1/R, since Ohm's law, rightly interpreted, holds as well for an alternating as for an unvarying current.

The quantity of electricity carried across a section of a conductor is equal to the current multiplied by the time it has flowed, so that the shaded area, enclosed by the current curve and O t_1, gives the number of coulombs so transferred during the time, O t_1, the current has been flowing in one direction. At t_1, the current reverses and flows in the same manner as before during an equal interval of time but in the opposite direction, so that an equal number of coulombs, shown by the area included by the current curve and t_1 t_2, is carried back across the section in the reverse direction. It follows, therefore, that no matter how long the machine has been running, the greatest quantity of electricity that can ever have been permanently transferred across the section is equal to one of these areas; and this, indeed, occurs only if the current is stopped when at the point of reversal, and one more pulse has passed in one direction than in the other.

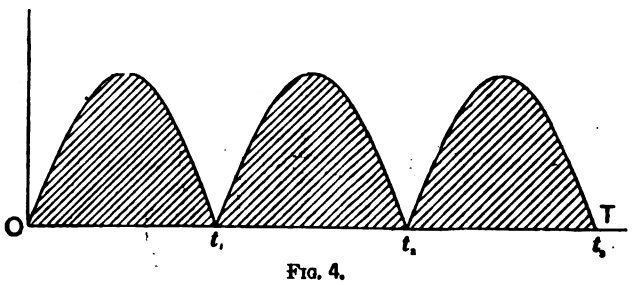

Fig. 4.

Clearly, then, the silver voltameter is useless for measuring such a current; as a whole, as much silver would be carried in one direction as in the other, and since the reversals usually take place hundreds or thousands of times in a minute, it is out of the question to obtain any indication at all of the current from this instrument.

But the current may, after leaving the armature coils, be sent through a commutator from which the pulses always pass in the same direction into the external circuit (Fig. 4). This being done, the current beyond the commutator will be represented by Fig. 4; if it is now passed through the voltameter, silver will be deposited, and after any suitable interval of time the deposit will measure the number of coulombs shown by the areas drawn for the same interval of time. If the number of coulombs registered by the voltameter be divided by the time, the quotient, which is the *time average* of the current that has passed during the interval, gives the value of the unvarying current which would have delivered the same number of coulombs in the same time.

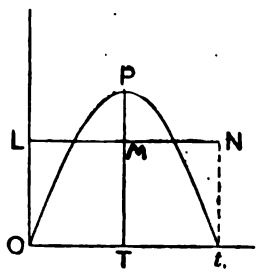

Fig. 5.

If O Pt_1 (Fig. 5) represents a single pulse of the current whose value varies from zero to a maximum P T, and similarly L N, the unvarying current which would have deposited the same weight of silver, then the area O L Nt_1 equals the area O Pt_1, and M T is the average height of the curve O Pt_1, or, since Ot_1 represents time, *the time average of the current at each instant.* In the case under consideration, O Pt_1 is a sine curve, and M T equals 0·637 P T.

(To be continued.) 196

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THE INSULATION OF ELECTRIC WIRES AND CABLES.

The long interval which will elapse between the reading of and discussion on Mr. Preece's Paper * on the Specification of Insulated Conductors, should give plenty of time for manufacturers to prepare matter for a good debate, and to carefully reconsider their methods of describing their wares. The idea of specific insulation which is prominently brought forward in this Paper forms the subject of a section in Mr. Kempe's book on Electrical Testing. It is open to question whether, having the words "conductivity" and "resistance," we need a third word. Many people shrink from using such numbers as $1{\cdot}09 \times 10^{25}$, for fear that a decimal place may get wrong in their calculations, and, while the idea of a cubic quadrant seems at first sight to be an exaggerated application of the C.-G.-S. system in a most pedantic form, it turns out, by a most fortunate coincidence, to be exactly that dimension which will give us round numbers with the fewest possible decimal places, to express the resistance, or, as Mr. Preece calls it, the insulation of dielectrics. Mr. Preece's table, which should include recent measurements of gutta percha, and, if possible, the compounded braid and tape with which electric light cables are covered, ought to be embodied in all engineers' pocket books and other works of reference. It is true that in practice we generally regard insulators as offering so much "insulation," and not so many ohms or megohms, since the leakage current is as a rule negligible; but, on the other hand, it is only by considering the leakage current that we can form a definite idea of the real degree of insulation of a conductor, which is somewhat loosely termed its "efficiency," near the end of the first paragraph of Mr. Preece's Paper. This point is an eminently practical one; and when once it is realised that it is the leakage current and not the megohms per mile that we want to know, it becomes difficult to see why manufacturers should have adopted the mode of classification at present in vogue, which results in a 61/12 and a 7/20 cable being placed in the same category merely because they are both given an insulation resistance of 5,000 megohms per mile; their "efficiencies" being, however, of a widely different order. This practice of talking about megohms per mile, like the use of binding screws, is a legacy bequeathed to us by the old school of electricians, an interesting relic of submarine cable construction; it is not only useless, but misleading in engineering work.

Many lists contain no information as to the diameters of cables; although such information might be considered as the first practical step in the direction pointed out by Mr. Preece. But it is not the diameter so much as the thickness which really gives the useful information. We do not remember any list giving the thickness. Given a "class" which is found to be generally satisfactory, the thick insulation of the large sizes becomes wholly unnecessary electrically, while in the smallest sizes the covering is often mechanically too thin. The mechanical qualities of insulating materials have not received much attention in Mr. Preece's Paper. There are at least three mechanical considerations—the strength of the covering to protect the conductor from contact with other conductors forced against it, as, for instance, when a telephone wire falls across an overhead wire; the strength needed to stand dragging into tubes, &c.; and, lastly, the flexibility needed to ensure freedom from cracks when the cable is handled during work, and when in its final position it is bent round sharp corners. More than one engineer of our acquaintance is of opinion that some mechanical test should be made especially for flexibility, and some suggestions will probably be forthcoming when the Paper is discussed. An excess or a deficiency of covering is detrimental to mechanical strength. The former is to be found in the insulation demanded for overhead wires by the Board of Trade, and the latter in some of the small wires used for house work.

The small circumference of a No. 19 wire enables a fair insulation to be obtained by means of a very thin and weak skin of india-rubber; but when a pull is given to the wire by grasping the covering, the braiding will sometimes stretch and extend the rubber, which sooner or later cracks. No. 19 is indeed much too small for ordinary wiring, and No. 17, if not No. 16, should be the smallest size allowed. The price of No. 19 is about 25 per cent. less than that of No. 17, and 32 per cent. less than No. 16 of fair quality. The difference is, of course, greater in low classes. The cost of insulated wire and cable comes to about 7s. 6d. to 8s. per lamp for the ordinary run of work, and one-half of this may be taken as small wire. The difference between No. 19 and No. 16 amounts then to only one or two shillings per lamp, or about *five per cent.* on the whole cost of wiring. Where greater flexibility is needed, the finely-stranded cables of 3/22 or 7/25 are very useful, and the use of smaller sizes, such as 18 or 19, should only be permitted in special cases for wiring fittings which will not take larger diameters. Between an inferior class of No. 19 and a fair class of No. 16 there is a difference of a hundred per cent., and this makes the need for accurately specifying the quality the more important. The use of smaller wire than No. 18 is prohibited by several London supply companies.

The great thickness of insulation required for high voltages by Mr. Preece and by the Board of Trade is quite unnecessary as an insulation, and is intended only to afford protection against sparking through cracks. It is by no means essential that the whole thickness should be made up of first-class insulating material, and experiments are needed to settle how disruptive discharges behave when they take place through cracks. A good coating of pure and of vulcanised india-rubber near the wire, and the rest of the thickness made up of strong fibrous material well "compounded," would seem to be the best arrangement. The insulation would be provided by the one, and mechanical strength by the other. Thoroughly well-woven braiding cannot crack like a homogeneous sheath of rubber. It is far stronger in every way, and a tolerable insulator.

In dealing with the question of sparking distance, the virtual alternating volts should not be taken, but the maximum. For most dynamos, especially those without iron in the armature, the maximum volts may be taken as one and a-half times the virtual. In such dynamos as those recently described by Mr. W. B. Lewis (*The Electrician*, Nov. 27, p. 91) some idea as to the maximum should certainly be obtained. The experiments of De la Rue and of Sir W. Thomson showed that for low volts the sparking distance was approximately as the square of the volts. Beyond 1,500 the curve connecting volts and sparking distance is practically a straight line. This line produced cuts the axis at about 700 volts. The volts may, therefore, be represented by 4,000 times the sparking distance in millimetres + 700. The experiments described by our German correspondent (*The Electrician*, Vol. XXV., p. 754) yield a practically straight line, passing through 2,000 volts, the volts being 5,000 times the sparking distance in millimetres + 2,000. These latter experiments were made with alternating currents and step-up transformers, and it is doubtful whether the ratio of transformation can be accepted as a correct indication of the volts.

Experiments with steady pressures give much larger sparking distances than with alternating pressures, and the results of observations with alternating currents are very discordant. A large number of causes determine the production of a spark, and it is very doubtful whether the results of experiments with points, balls, or plates are at all comparable with the case of a wire of indefinite diameter buried in a cracked mass of rubber or other insulator. In any case we cannot accept Mr. Preece's rule-of-three sum without considerably more experimental evidence than has yet been brought forward. Dr. Fleming has found that the 2,400 volts of the London Electric Supply Company will not spark across $\frac{1}{32}$nd of an inch (·794 millimetre), and as no authentic example of an accident from this cause has been recorded, the matter can well wait until the general discussion is taken. Two equally important, but still more obscure failures of insulation are to be found in the actual piercing of solid dielectrics, and in the "creeping discharge," which is very marked at pressures of 20,000 to 30,000 volts, but which seems to exist in another form in the presence of moisture at 100 or even 50 volts.

Mr. Preece has not clearly stated how he proposes a manufacturer's list of cables should be drawn up; but we gather

* *The Electrician*, Dec. 11, p. 146.

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indirectly from the opening paragraph that what he calls the efficiency should be the same for all cables of one class. This would be a thoroughly rational system, and in exact harmony with the well-known rules for the insulation of complete circuits, viz., that the insulation should be inversely as the number of lamps, or, more simply, that the leakage current must bear a constant proportion to the main current. A mile of cable offering 1,000 megohms per mile allows under a pressure of 100 volts a leakage current of $\frac{1}{10}$th of a micro-ampere. If this be considered suitable for a cable of, say, 7/16s, carrying 20 amperes, the insulation might be defined by the rule that the leakage current per mile must not exceed one two hundred millionth part of the working current. Other cables insulated to the same degree of "efficiency" would have an insulation proportional to the square root of their diameters, since the leakage depends on the circumference, while the carrying capacity depends, in most practical work, on the sectional area. But we are at once met by the absurdity of considering such a leakage current as one ten-millionth of an ampere. If it were a hundred or a thousand times larger or smaller no one would be any the wiser; and though the system may be truly rational it can hardly be said to be practical, unless in an indirect sense to which we shall allude presently. The Board of Trade demand for "continuous insulation" 100,000 ohms per mile for every volt, which limits the leak to ten micro-amperes at 100 volts, or one hundred times the leakage assumed in our example. A cable of the unheard of insulation of 10 megohms per mile would therefore meet the Board of Trade requirements for 100 volts. It appears from the very practical letter which we recently received from Mr. Sutton* that cables of a lower class than 150 megohms per mile are not adapted for testing under water, so they must be taken for what they are worth without the description afforded by such tests. The deeper we plunge into calculations based on these megohms, the more impractical does this mode of specification appear, and there is little doubt that Mr. Sutton's observation gives the real and only meaning, viz., that "for a given thickness of insulation, the megohm test is a true indication of the quality of the material and the workmanship." Mr. Sutton offered a timely warning against the acceptance of the diameter of the cables as an indication of the thickness of the insulation; and although the value of the mechanical protection afforded by tapes and braiding yarns is often underestimated, we should like to see the thickness both of the insulating material and of the outer serving given in the makers' lists. We have tried to apply Mr. Kempe's approximate formula to the list of a well-known firm of cable makers; but having only the outside diameter to go upon, the values of the "specific insulation" are quite discordant, a class which is described as "600 megohms per mile" giving very irregular specific insulations, varying from ·58 to 1, and showing no connection between the quality and the thickness, as might be expected. Mr. Sutton's remarks as to the true use of the megohm test show that this, in conjunction with information as to the thickness of the insulating material, will, by the aid of Mr. Kempe's approximate formula, give a good idea of the electrical qualities of a cable or wire; and it is to be hoped that in future lists the value of σ will be given at once, and thus save the trouble of working it out. The megohms per mile should vary throughout each class, and need not be given when once the new system is understood; or, at the most, it might be quoted for one particular size, say 7/16s in each class. Not only the megohms, but the specific insulation depends on the way in which the test is carried out. Mr. Preece puts forward the clear statement that one minute is universally accepted as the period of electrification. This should be taken as a challenge to any makers who test in another manner. If they desire to continue their present system, they should come forward at the discussion and give their reasons. The water test, it must be remembered, can only be applied to certain kinds of cable, and is not applicable to various systems of conductors used for supply mains.

The table of values of σ of different kinds of electric light cables given in Mr. Preece's Paper would have been much improved by the addition of the "classes" in which they are at present placed; thus the Silvertown examples appear to be something very different from their well-known qualities; even their 19/15 L, the most expensive class, comes only to $\sigma = 7$, taking the diameter ·758 given in their October list, while in Mr. Preece's Papers we have σ equal to more than 11. We must not trench on the subject of price; it is considered improper to compare prices too closely or analytically, but the table would also have been still more interesting if it had related to cables of about the same price.

With regard to the first clause of the specification proposed by Mr. Preece, we cannot but think that it savours too much of the electrician, and too little of the engineer. The conductivity of the copper is a matter of no importance whatever to the consulting engineer or to his client when the fall of volts is specified as it always should be. This is clearly another relic of telegraphic practice and should be set aside as an unnecessary complication. The result of employing a low conductivity only means that two or three per cent. greater weight of metal will be used. The contractor must, of course, beware of miscalculating his resistances, but an error quite comparable to that due to variation of conductivity is often neglected, viz., the effect of the "lay" in increasing the weight but in diminishing the resistance. Mr. Connolly recently gave some information on this subject (*The Electrician*, Vol. XXVI., p. 435), but even he had not considered the exact difference until we called attention to it.

The 7th, 8th, 9th, and 10th clauses in the specification refer to matters which we hope will be clearly dealt with in makers' lists. The 8th clause should not supersede the quotation of the over-all diameter of the cable, which it is often very necessary to know. The method of testing is alone a subject that might be discussed at great length, and here Mr. Preece's advice is thoroughly in accordance with engineering practice. There is unfortunately no factor of safety as in boiler or steam-pipe work. A test of from 1½ to twice the working pressure is the ordinary custom in the boiler-shop, and amounts to from one-third to one-quarter the assumed bursting pressure. A test for 24 hours at 1½ times the working volts, the cable being handled either by coiling in and out or recoiling in the tank, should be an ample test. A test made when tightly coiled on a drum—perhaps coiled while warm—is but little guarantee of the future behaviour of a cable. We learn with great satisfaction that two or three of the leading makers of electric light cables intend to revise their lists; and whether they do so at once, or wait until this Paper and the one promised by Mr. Alexander Siemens have been discussed, Mr. Preece's communication cannot fail to have a most useful effect in calling the attention of both makers and users of insulated cables to points which are of such great importance to the efficiency and safety of electric lighting.

* *The Electrician*, November 27th, p. 98.

THE FRANKFORT EXHIBITION.—XVII.

(FROM OUR SPECIAL CORRESPONDENT.)

The firm of Lahmeyer, of Frankfort, has solved the problem of producing a safe compound motor in a very ingenious way. The danger of a reversal of polarity on suddenly increasing the load is avoided by using two magnetic fields acting on the same armature, the shunt and series coils being wound on different cores. The connections of the circuits are diagrammatically shown in Fig. 1. The shunt magnets *n n* are of much larger dimensions than the series magnets *d d*, and the field produced by them is the stronger even when the series magnets are highly saturated by an excessively heavy main current. The machine has been christened the "long-lead" motor, since the volts lost in the leads, which would have a very marked effect on the speed of a pure shunt motor, are here inoperative as a factor producing variable speed with varying load.

The Offenbach-Frankfort transmission of power, although not calculated to impress the public as much as that from Lauffen, was of interest to engineers. During the Exhibition direct current alone was used, but soon after its close, Herr Lahmeyer was enabled to use the three-phase current.

First, as regards the direct current. At Offenbach, 6¼ miles by the wires from the Exhibition, there was a four-pole drum

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armature 50 kilowatt dynamo. The magnets were excited by a 110 volt current, and the excitation regulated by a resistance so that a constant voltage of 2,000 was always maintained at the terminals of the machine. The transmission wires were ·24 in. in diameter, and the loss of pressure in the leads with the maximum current of 25 amperes was about 200 volts. The between 0 and 25 amperes, a constant pressure of 2,000 volts was supplied to the high-pressure brushes of the "dynamotor" or continuous-current transformer at Frankfort. The drum armature of this machine has, as usual, two windings and two commutators, for high and for low pressure. The machine is four-pole, and the initial excitation is given by a few high-pressure series

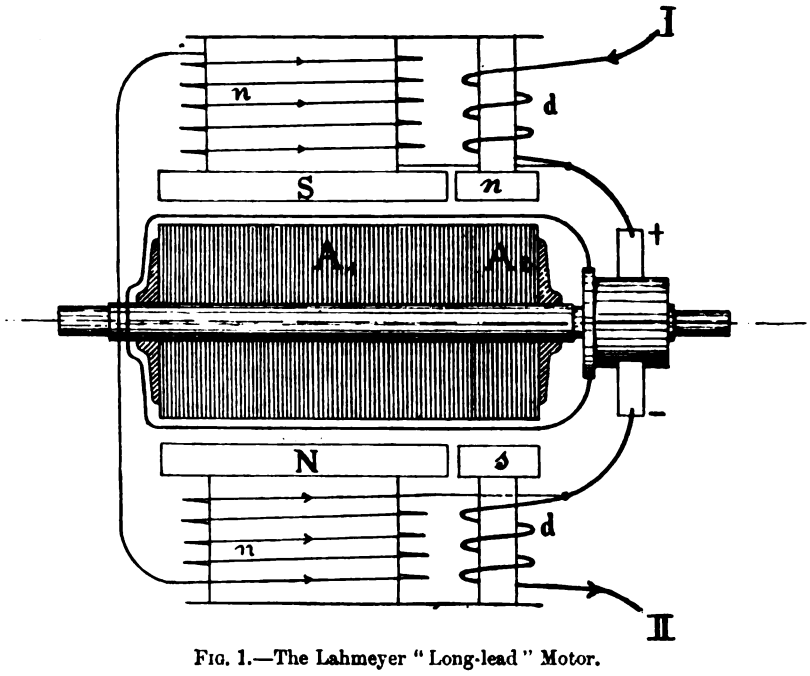

FIG. 1.—The Lahmeyer "Long-lead" Motor.

object of the transmission was to supply secondary current at Frankfort at a pressure of 110 volts. Two methods were alternately employed.

The first method involved the supply of current at a constant pressure of 2,000 volts *at* Frankfort, and to ensure this a small series-wound dynamo was circuited at Offenbach in turns. These turns are wound under the shunt coils, taken off the low-pressure commutator, and are separated from them by thick insulation. As soon as the dynamotor is started (switched on as an ordinary series motor with a liquid resistance in circuit) the low-pressure wires on the armature are the seat of an electromotive force, and current from them passes

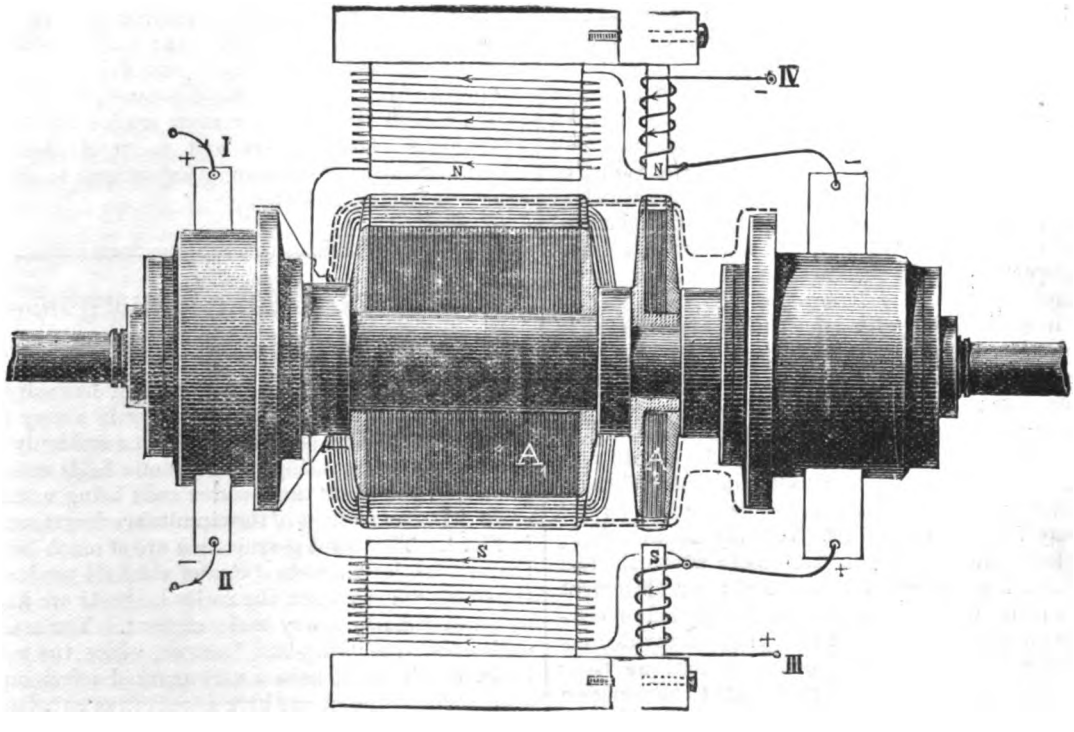

FIG. 2.—The Lahmeyer Dynamotor.

series with the primary dynamo. The result of this was that, with maximum load on the line, there was an additional 200 volts at Offenbach giving about 2,000 at Frankfort, and of course with no current the magnets of the series-wound dynamo were not excited, and there were, therefore, no additional volts. By this device, for all currents round the low-pressure coils on the magnets, and increases the magnetism induced by the high-pressure coils; these, together with the liquid resistance, are, by means of a step by step switch, then cut out of circuit. The machine is then excited by low-pressure current alone, and by a simple mechanism, which is automatically locked, while the high-

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essure current is going round the magnets, the high-pressure agnet *coils* can be circuited in parallel with the low. It is ıly when the motor is to be stopped that there is a break in ıe high-pressure circuit, and an ingenious switch is used, ·ovided with a knife, which cuts through the spark at the stant of break.

the following simple way of averting this danger. Between the high and low-pressure windings there is a metallic screen, usually of copper gauze, which is divided into two parts by insulation to avoid Foucault currents, each part being joined to earth. If any high-pressure rupture occurs, the current would not pass through the metallic screen, but would go to

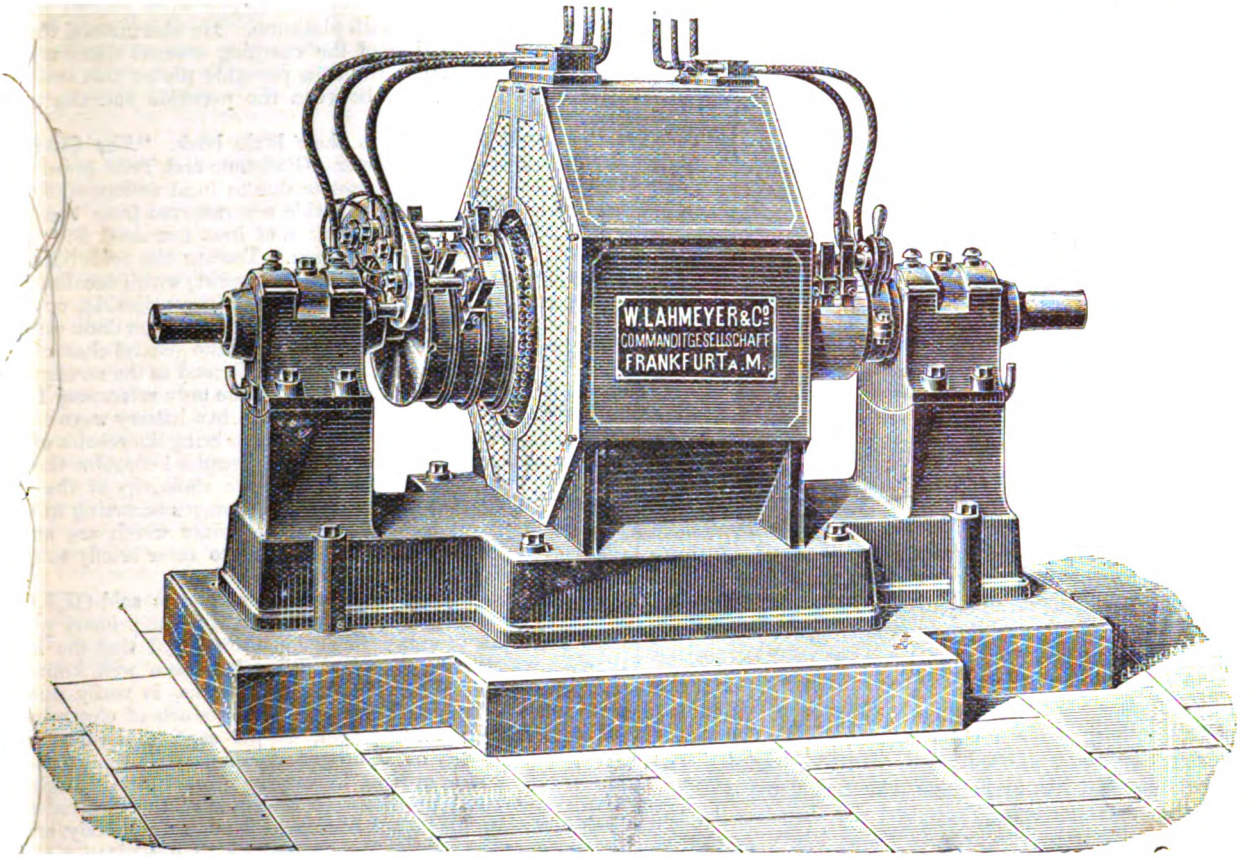

FIG. 3.—The Lahmeyer Three-Phase Dynamotor.

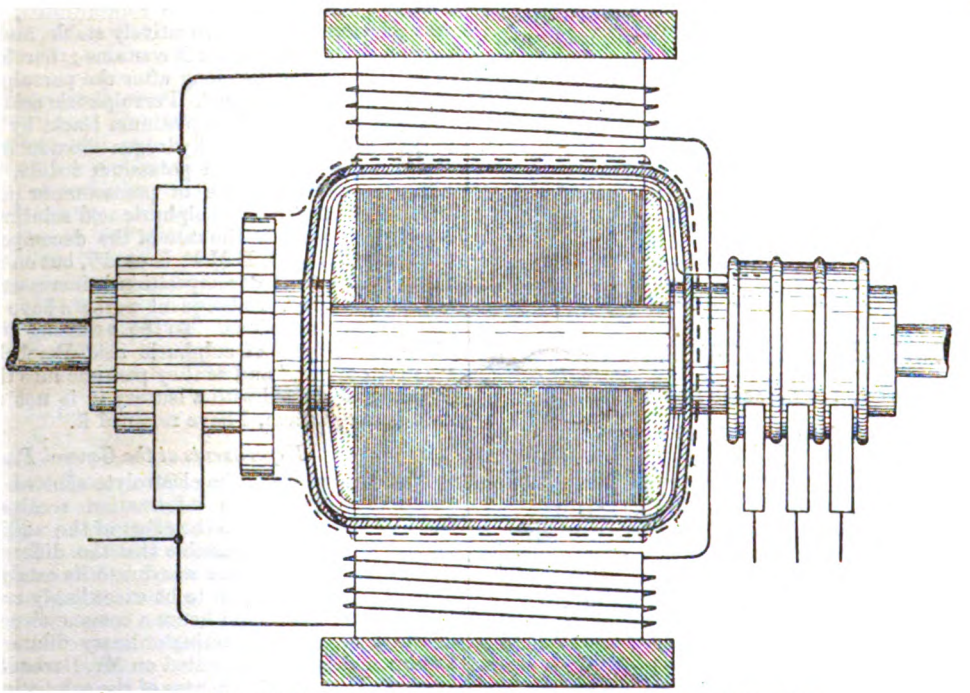

FIG. 4.—Diagram of Connections of the Lahmeyer Three-Phase Dynamotor.

It was to be feared, of course, that as the high and low-pressure wires lie one under the other on the armature, in case of a fault in the insulation the 2,000-volt current would find its way into the low-pressure wires, and so prove a danger to the users of the current. In addition to relays intended to break all contacts in such a case, Herr Lahmeyer has devised

earth. This safeguard is used by Herr Lahmeyer in his high-pressure machines whenever possible. In the dynamotor just described, it was found possible to keep the secondary pressure constant to within 4 per cent.

In the other continuous current plant, the auxiliary dynamo employed to compensate the loss of volts in the leads was

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dispensed with; and the pressure at Frankfort varied from 2,000 to 1,800 volts, according to the load. The transformer used in this system has two magnetic fields, as shown in the diagram (Fig. 2). The high-pressure current supplied through brushes I. and II. is taken round the armature A_1 alone (with the exception of a few additional turns for initial excitation as before); the low-pressure coils surround the armature core A_1 in addition to the second armature core A_2. The field-magnet coils are arranged as shown in the figure, the low-pressure terminals being III. and IV. From the diagram it will be seen that the following conditions necessary for a constant secondary pressure under a varying load can be fulfilled by this system if the dimensions are properly chosen. With an increasing load the motor armature requires a small decrease in its magnetic field to keep the speed constant. The dynamo armature, on the contrary, requires a corresponding increase of field strength in order to compensate the increased loss of volts in the armature. Owing, no doubt, to the constancy of the resultant field sparking was entirely absent from the secondary commutator at change of load, and once adjusted the dynamotor required no attention. Both these machines have fulfilled the high expectations formed of them before the Exhibition.

As regards the three-phase current transmission, it was so simple and successful that a few words will suffice to describe it. In Offenbach there was a four-pole drum-armature dynamo excited by a 110-volt current. By means of rings and brushes three currents of 120deg. phase difference were taken from the armature and led by three wires to the three brushes of a corresponding machine at Frankfort. This machine (Fig. 3) needs a little description. It is, in fact, the continuous current transformer or dynamotor first described, which was supplied with a constant pressure of 2,000 volts. The high-pressure commutator was taken off, and three rings fitted on in its place, the two armature windings remaining just as before, the high-pressure coils used on the field-magnets for initial excitation being unused. (*See* diagram, Fig. 4.) The rings are connected with points on the armature 120deg. apart, and the current being supplied by brushes in the usual way, the dynamotor starts (without load), no initial excitation being needed, and as soon as synchronism is shown by the voltmeter to have been reached, the shunt windings from the low-pressure brushes are switched in and finally the lights. Between any two of the 6¼ mile conductors the mean potential difference was about 1,300 volts; but in consequence of the synchronism the pressure variations which occur from variable losses in the leads with varying loads have no effect on the constancy of the secondary 110 volts. The smooth noiseless running of this transformer of three-phase to continuous current was particularly striking. It required absolutely no attention during long runs with different loads, and there was no sparking whatever.

SECONDARY BATTERIES.

BY G. H. ROBERTSON, F.C.S., ASSOC.INST.EL.ENG.

(Concluded from page 146.)

The Chemistry of the Acid.

Although so many different modes of manufacture and preliminary treatment have been resorted to, all the batteries, so far as I am aware, which depend for their action on the couple formed between lead and lead peroxide in dilute sulphuric acid, exhibit the characteristic peculiarities noticed by Planté in his cell, namely, the high initial E.M.F. of a freshly-charged cell; the fall of E.M.F. on breaking the charging circuit, with corresponding rise on breaking the discharging circuit; the very rapid fall towards the end of discharge which occurs earlier the more rapid the discharge is, and is not due to the exhaustion of the active material, as after a rest a fresh discharge can be obtained.

As the defects, namely, sulphating and buckling, which have retarded the introduction of reversible lead batteries, are also common to the two types, it appeared possible that they were due to the same causes which produced the variations in E.M.F.; therefore, as the work of Dr. Oliver Lodge* in 1883, and of Mieslert in 1888, had shown that the causes of the variation must be sought either on the lead plate or in the acid next it, and the chemistry of the plates afforded no explanation*, I last year, with Dr. Armstrong's advice and assistance, undertook the investigations of the reactions occurring in the acid.

Planté† had considered that the peculiarities in E M F. were due to the formation of peroxides in the acid, and showed that the conditions existing in a cell were favourable to their production, since in voltameters with lead electrodes they were formed in greater quantity than in those with platinum. He also noticed that immediately on the cessation of the charging current there was often a small evolution of gas from the peroxide plate; this evolution he ascribed to local action between the peroxide and the subjacent lead.

Commenting on this in their little book, "The Chemistry of Secondary Batteries," Messrs. Gladstone and Tribe point out that the gas is oxygen, and cannot be due to local action, since the gas was evolved whether the peroxide was removed from the supporting plate or not. The application of heat increased the evolution of gas, and the gas was oxygen. Testing the acid between the plates they always found traces of something which decolourised permanganate, and might, therefore, be hydrogen dioxide, or ozone.

Although a very large amount of work has been done on the electrolysis of sulphuric acid solutions, and the general character of the change in the nature of the products formed as the strength of the solution is varied is well understood, the only references I was able to find to any examination of the acid in a battery were those just given, and therefore, I have ventured to bring the results of my own experiments before this Society, not because I consider them a final solution of the difficult problem of the chemistry of the cell, but because I hope that the study of the changes occurring in the electrolyte may help to elucidate some points which are at present obscure. And now it may be as well to refer briefly to the work which has been done in sulphuric acid.

In 1878, Berthelot‡ discovered persulphuric acid ($H_2S_2O_8$), and brought forward evidence to prove that it is the primary product of the electrolysis of sulphuric acid solutions, and that the hydrogen dioxide, which from Faraday's time has been well known to be present in sulphuric acid after electrolysis, is really due to the action of this body on the acid. The products of electrolysis vary with the strength of the acid, 40 per cent. acid (density 1,300) yielding practically no hydrogen dioxide, while below and above that strength it is present in varying proportions. High-current density and an electro-negative condition of the electrodes favour their formation.§ Persulphuric acid is an unstable body, and begins to decompose as soon as the current which has given rise to it is stopped, and its decomposition is accompanied by the formation of hydrogen dioxide, unless the sulphuric acid is too dilute. Hydrogen dioxide is also unstable when concentrated, but a weak sulphuric acid solution of it is comparatively stable, and the stability increases the less hydrogen dioxide it contains; therefore, this body is found in estimable quantities long after the persulphuric acid, which gave rise to it, has disappeared. Persulphuric acid is at once decomposed by spongy metal, such as platinum black, by heat with evolution of oxygen ||, and resembles hydrogen dioxide in these reactions, and in releasing iodine from potassium iodide, but, unlike it, has no action on permanganate of potassium or peroxide of lead. The effect of electrolysing a sulphuric acid solution of hydrogen dioxide is simply to increase the rate of the decomposition occurring spontaneously if a weak E.M.F. is used¶, but on increasing the E.M.F. though the rate of decomposition is increased, a little persulphuric acid is re-formed. Subsequent workers have in the main confirmed Berthelot's conclusions. To the oxidising oxygen in the products of the electrolysis of sulphuric acid Berthelot gave the name of "active oxygen," and as they pass one into the other, and for most purposes connected with a battery it is not necessary to discriminate between them, I have retained it.

Experiments at the General Post Office.

That the nature of the electrolyte affected the behaviour of the cell was evident from information received from Mr. Barber Starkey with respect to the effect of the addition of sodium carbonate; and it seemed possible that the different behaviour of cells containing this substance was due to its catalytic action on hydrogen dioxide, which is known to be exceedingly unstable in the presence of a trace of alkali, and hence a comparative study of the reactions occurring in cells containing ordinary dilute sulphuric acid, and in those which had been treated on Mr. Barber Starkey's plan, seemed likely to elucidate the causes of the sulphating during rest, and the high initial E.M.F., the two features most affected by his treatment.

* "Cantor Lecture." † "Monatshafte fur Chemie" VII., 713.

* For references and a summary of the principal work done on the cell, see *The Electrician*, Vol. XXVII., No. 682, p. 165; No. 697, p. 437.

† "Recherches sur l'Electricité."

‡ Berthelot, *Compt. Rend.*, 90, 269–275.

§ Richarz, *Ann. Phys. Chim.* [2], 31, 912.

|| Berthelot, *Bull. Soc. Chim.* [2], 34, 78—81.

¶ Berthelot, *Compt. Rend.*, 95, 8—11.

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Mr. Preece most kindly aided the investigation by allowing experiments to be carried out at the General Post Office, where one half of the secondary cells contain 1 per cent. of sodium sulphate, and the other half ordinary dilute acid, density 1,180. He also put at my disposal the records of the behaviour of the cells, and they proved that there was much less sulphating with sodium sulphate, as shown by the density of the acid never falling to the same extent as in the plain cells.

The following readings, taken from short-circuited cells with badly broken plates, illustrate this. In two cells containing ordinary dilute acid the density of the electrolyte had fallen to 1,100, while according to the last readings before the short-circuit occurred it had been 1,170 and 1,180 respectively; while in two sodium sulphate cells the density had only fallen to 1,180 from 1,200 under similar circumstances.

This was strong evidence in favour of the hydrogen dioxide formed in the working of the cell being appreciable in quantity, since if sulphating were only due to local action between the support and the paste there does not appear any reason why the addition of sodium sulphate should affect it.

Whenever the cells were tested they were always found to contain "active oxygen," which was due to the presence of persulphuric acid and peroxide of hydrogen in varying proportions. During charge persulphuric acid is the main constituent; during discharge the quantity of hydrogen dioxide gradually increases; while in a cell which has been at rest some time there is very little except hydrogen dioxide to be found.

In addition to the tests made on the cells in the electric light and telegraph batteries, I studied the formation of the "active oxygen" during charge and discharge on some cells which were kindly set apart for my special use. The "active oxygen" forms at once on the passage of the current, decreases slightly, and then increases to a little above its first value. Starting either charge or discharge always causes an initial increase, except in the case of cells which have been long idle; then there is a diminution due to the decomposition of the excess of hydrogen dioxide in the acid.

In the sodium sulphate cells the amount of the oxidising agent was usually less than in the plain cells; and the amount of hydrogen dioxide was always so unless the battery had been at rest for some time, when the conditions were occasionally found to be reversed. This, I suppose, is due to the proportion of "active oxygen" in the form of hydrogen dioxide at the moment of stopping the current being greater in the plain than in the sodium sulphate cells, while the latter contain more persulphuric acid. In both cells the hydrogen dioxide present at the time of stopping the current will be reduced on the plates, sulphating the surface, and more or less screening them from further action; but as the sodium sulphate cell contains more persulphuric acid, the subsequent formation of hydrogen dioxide will be greater in it than in the plain cell. As far as I could discover sodium sulphate has little or no action on the acid unless it is added during the electrolysis, or to acid which has just been taken from a cell through which a current is passing.

The Pink Colour o the Acid.

It has often been noticed, that during charge, particularly with new cells, a pink colour starts from the peroxide plates, and gradually spreads over towards the lead plates, fading away, however, before reaching them. This pink colour was referred to by Mr. Crompton at a meeting of the Institute of Electrical Engineers on December 13, 1890, and its origin gave rise to some discussion; so as the acid in many of the cells at the Post Office was pink, I tested it by concentrating it down, neutralising with sodium carbonate, and then igniting on platinum foil, and always got the characteristic green of manganese.

However, lest the manganese should have come from some other source than the pink acid, I compared the absorption spectrum of the acid with that of a solution of potassium permanganate of the same shade of pink, and found they both gave the characteristic bands in the green (Fig. 14). I also found that using two strips of platinum as electrodes in a solution of manganous sulphate, or any two strips of lead in dilute acid, gave the same colour and the same absorption bands, provided the electrodes were sufficiently far apart

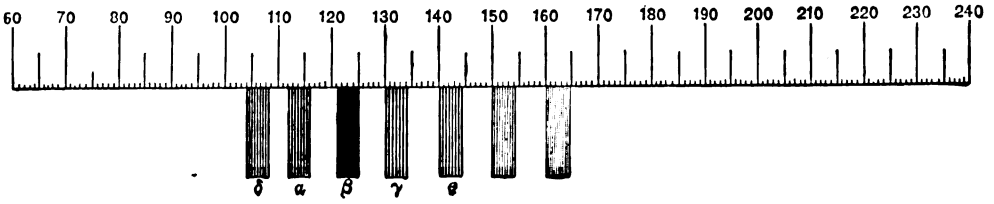

FIG. 14.—Absorption Spectrum of Potassium Permanganate.

To test whether electrolysed acid was able to reduce pure peroxide of lead, two equal lots of peroxide were taken by weighing one against the other, and put in two flasks. On to each 100 c.c. of acid from next the positive plate of a cell at full charge was poured, and this caused the evolution of oxygen, which continued slowly for some days. At the end of a fortnight the amount of peroxide of lead in each sample was estimated, and it was found to have decreased from 97·4 per cent. to 93·94 per cent. and 94·04 per cent. respectively.

This appears to explain the well-known deleterious effect of rest on a cell; for although persulphuric acid itself does not reduce peroxide of lead, it forms hydrogen dioxide on standing, which is capable either of oxidising the lead plate to litharge, or of reducing the peroxide plate to the same substance. In each case the litharge is converted into sulphate by the sulphuric acid.

In an ordinary cell in good order the amount of "active oxygen" is small, varying in quantity from about 0·01 grm. to 0·02 grm. per litre; but this means that in a 45-pint cell (the size used at the Post Office) there was always sufficient to convert from 3·25 grms. to 7·5 grms. of peroxide of lead into sulphate, or to undo the work of one to two ampere-hours charge.

This is not a serious matter if the cells are kept working, as the peroxides are being continually broken up with each reversal of the current; but if the cells stand idle the plates get sulphated, and the amount of "active oxygen" formed in the next passage of the current shows a marked increase.

The figures just given do not represent the total amount of "active oxygen," since the acid absorbed by the plates cannot be tested; but as the acid has more oxidising power the nearer you get to whichever is the positive plate, except at the commencement of discharge, and the total quantity of "active oxygen" increases rapidly soon after breaking circuit, it seems fair to assume that this increase is due to diffusion from the plates of acid, which has more oxidising power than that in the body of the cell.

This increase is followed by a decrease which is rapid at first, and then gradually gets very slow, and practically ceases while there is still a fair proportion of "active oxygen" left in the cell.

to prevent reduction by the hydrogen evolved from the negative. This result was important, for it is well known that the pink colour disappears from the acid in a short time if it is taken from the cell, and as persulphuric acid has no action on permanganate, but hydrogen dioxide decolourises it, this disappearance of the colour shows that the latter is formed.

The Effect of Hydrogen Dioxide on the E.M.F. of a Cell.

The presence of hydrogen dioxide having been thus proved, both directly and indirectly, its effect on the E.M.F. of the cell was tested. This was done by using strips of lead packed tight into small porous pots, with peroxide of lead to represent the peroxide plates, and using plain strips as the lead plates. A solution of pure sulphuric acid, density 1,180, was used as the electrolyte. The E.M.F. of the couple was taken by the deflection method, and then a drop or two of hydrogen dioxide was added to the acid, which produced a great diminution, or even reversal of the E M.F.

The effect of introducing hydrogen dioxide into the body of the peroxide paste was also tried, with a view of reproducing, if possible, the conditions of a cell which is started discharging directly the charge is completed, and in which the "active oxygen" would be accumulated at the positive plate, leaving the lead plate free, and I found that there was a slight increase in E.M.F.

Thus the variations in E.M.F. appear to depend on which plate hydrogen dioxide is formed at. When present at the peroxide plate it causes a rise, but when diffused through the acid and present at the lead plate, it causes a lowering of the E.M.F.; and the rise in E.M.F., sometimes noticed on starting the discharge of a cell which has been at rest (mentioned in Prof. Ayrton's Paper, *Journal Institution Electrical Engineers*, 1890, p. 572), is probably due to the electrolysis and decomposition of hydrogen dioxide; for in a cell which has been long idle, practically the whole of the "active oxygen" is due to this body.

Conclusions.

From the same faults appearing in batteries of such different construction, and judging also from the results of the experiments

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recorded in this Paper, it would appear that the troubles occurring in batteries are due rather to causes arising in the working than in the manufacture. What is required is some substance which can be added to the acid to check the formation of the oxidised bodies in it which cause sulphating, without at the same time injuring the plates in other ways.

Nearly all the "forming" baths which have been introduced are baths in which hydrogen dioxide would be broken up as soon as formed, and perhaps in some modification of them the electrolyte of the future will be found; though, since the products of the electrolysis of sulphuric acid vary with the strength of the acid, and the current density, no hard and fast rule can be laid down for the treatment of cells.

In cells containing acid below density 1,200, in which the proportion of "active oxygen" existing as hydrogen dioxide is high, the addition of 1 per cent. of sodium sulphate, or similar substance, is likely to prove beneficial, particularly if the work of the cells is intermittent. As the strength of the acid is increased, however, and the conditions are more favourable to the stability of persulphuric acid, less hydrogen dioxide will be produced, and there is more chance of the alkali released from the sodium sulphate during electrolysis damaging the plates.

Also, Dr. Marshall has succeeded in preparing pure persulphuric acid, and has shown this year that it forms salts with the alkalis, which are very stable; and what the effect on a cell of the formation of sodium persulphate in it would be, is quite unknown. Although the formation of peroxides in the acid does not apparently account for the great gassing and sudden loss of charge sometimes observed, still we have seen that makers are reverting to Planté's process of manufacture, or modifications of it, and we may find that in this case also he was right, and that it is to the electrolyte we must look if we wish to find the means of materially improving the lead reversible battery.

In conclusion, I must thank the firms who have assisted me in the compilation of this Paper by supplying information in response to circulars sent out.

PHYSICAL SOCIETY.

At the meeting of the Physical Society on December 4th, the following Papers were read :—

'A Permanent Magnetic Field,"

by W. HIBBERT. The author had noticed the approximate constancy of an "aged" bar magnet, and he obtained still greater constancy by attaching pole pieces to a bar magnet of such a shape as to give a nearly closed circuit of small "magnetic resistance." The pattern now described consists of a steel rod, 1in. diameter, and about 2½in. long, with a cast-iron disc, 4in. diameter, and ⅝in. thick, fixed at one end; the other end is fitted in a hemispherical iron shell, which surrounds the bar and comes flush with the upper surface of the disc. An annular air space, less than $\frac{1}{16}$in. wide, is left between the cylindrical surface of the disc and the inside of the shell, and when the bar is magnetised, a strong magnetic field exists in this space. To use this field for producing electromagnetic impulses, a coil of wire is wound in a shallow groove on a brass tube which can slide easily through the annular space, thus cutting all the lines. The tube is allowed to fall by its own weight, a neat trigger arrangement being provided for effecting its release.

The instrument exhibited had 90 turns of wire in the coil, and the total magnetic flux across the air space was about 30,000 C.G.S. lines. A large electro-magnetic impulse is therefore obtainable, even through resistances as great as 10,000 ohms Tests of three instruments show that there has been practically no magnetic decay in seven months. The author, therefore, considers them satisfactory, and is prepared to supply them as magnetic standards. To facilitate calculation, the number of lines will be adjusted to a convenient number, say 20,000 or 25,000.

Several uses to which the instruments are well suited are mentioned in the Paper, and a simple way of determining permeability by the magnetometer method is described.

DISCUSSION.

Mr. BLAKESLEY thought the name given to the instrument was inappropriate, for it really gave a constant impulsive E.M.F.

Dr. SUMPNER said the constancy of the sensibility of d'Arsonval galvanometers was a measure of the constancy of magnets having nearly closed circuits. Such instruments in use at the Central Institution had remained unchanged for several years.

Prof. S. P. THOMPSON admired Mr. Hibbert's instrument, and thought it would be very useful in laboratories. Standard cells, he said, were not always reliable, and condensers were the most unsatisfactory of electrical standards. On the subject of permanency of magnets, he said that Strouhal and Barus found that magnets with nearly closed circuits were most constant, and that to give the best results, the hardness of the steel should be less the more closed the circuit. Mr. Hookham had also found that by using a nearly closed circuit, and reducing the strong magnetisation by about 10 per cent., great constancy cou'd be obtained. Some years ago he (Dr. Thompson) had tried the effect of illtreatment on magnets, and observed that touching or hitting a magnet with non-magnetic material had little effect, whilst similar treatment with iron or magnets affected them considerably. Suddenly removing the keeper of a magnet tended to increase the magnetism, whilst putting a keeper on suddenly had the reverse effect. Strouhal and Barus had also investigated the temperature coefficient of magnets, and found that this might be reduced by subjecting the magnet to rapid changes of temperature after the first magnetisation, and then remagnetising.

Mr. W. WATSON inquired what was the percentage fall in strength of Mr. Hibbert's magnets. The bars used in magnetic surveys had been tested frequently, and they lost about 0·5 per cent. in six months.

The PRESIDENT (Prof. Ayrton) asked what was the temperature coefficients of the magnets described in the Paper. Mr. Evershed, he said, thought it was between 0·01 per cent. and 0·05 per cent. for ordinary magnets. He thought the instrument shown by Mr. Hibbert would be of immense value if the magnet was really permanent. By it ballistic galvanometers could be readily calibrated, and, when combined with a resistance box, it could also be used as a standard for current; for since the constant of a ballistic galvanometer for quantity can be determined from its constant for current, if the periodic time be known, conversely that for current can be found from the constant for quantity. In some instances this would be of great use Speaking of the temperature coefficient of condensers, he said that in some cases the specific inductive capacity of dielectrics diminished with rise of temperature whilst in others it increased.

Mr. HIBBERT, in reply, said he found the temperature coefficient of his magnets to be, roughly, about 0·03 per cent., but he had not investigated the matter very carefully. In making his measurements, no correction had been made for the variation of capacity of his condenser with temperature.

'Note on Rotatory Currents,"

by Prof. W. E. AYRTON, F.R.S. The subject, the author said, was probably familiar to most persons present, for it had been frequently referred to in the scientific papers. Alternate currents could be obtained from an ordinary direct-current dynamo by making contact with two points in the armature say by connecting these points to insulated rings on the shaft, and using extra brushes. A direct-current motor similarly treated transforms direct currents into alternating currents, or into mechanical power. If two pairs of points in the armature be selected, situated at opposite ends of two mutually perpendicular diameters, then two alternating currents differing in phase by 90deg. can be obtained; and by choosing suitable points in the armature, two, three, or more currents differing in phase by any desired angles can be produced. In ordinary motors the connection for doing this would be troublesome; but the Ayrton and Perry form, which has a stationary armature, lends itself readily to this purpose, for contact can be made with any part of the armature with great facility. A motor of this kind was exhibited, in which contact was made with four equidistant points on the armature. On connecting opposite points through fine platinum wires, and running the motor slowly, the wires glowed alternately, one being bright whilst the other was dark, and *vice versâ*, thus demonstrating the existence of two currents in quadrature. When the four points on the armature were joined to the four corners of a square of platinum wire, the wires became incandescent in succession, the glow appearing to travel round the square and suggesting the idea of rotatory currents. A Tesla alternating-current motor was also driven by two currents differing in phase by 90deg. obtained from the armature of the Ayrton and Perry direct-current motor above mentioned.

The case with which currents differing in phase by any amount can be obtained from such a motor, led the author to investigate theoretically the case of two circuits connecting opposite ends of two diameters inclined at any angle. Calling the currents in these circuits at any instant, A_1 and A_2, he had found that

$$A_1 = 2n E_0 \frac{\sqrt{\left(r_2+\rho\frac{\pi}{2}\right)^2+\rho^2\left(\frac{\pi}{2}-\alpha\right)^2-2\left(r_2+\rho\frac{\pi}{2}\right)\rho\left(\frac{\pi}{2}-\alpha\right)\cos\alpha}}{\left(r_1+\rho\frac{\pi}{2}\right)\left(r_2+\rho\frac{\pi}{2}\right)-\rho^2\left(\frac{\pi}{2}-\alpha\right)^2}\sin(pt+\phi).$$

where

E_0 = maximum E.M.F. per convolution,
n = number of turns on armature per radian,
ρ = resistance of armature per radian,
p = angular velocity of rotation,
r_1 = resistance of external circuit in which current A_1 passes,
r_2 = resistance of external circuit in which current A_2 passes, and

$$\tan\phi = \frac{\rho\left(\frac{\pi}{2}-\alpha\right)\sin\alpha}{r_2+\rho\frac{\pi}{2}-\rho\left(\frac{\pi}{2}-\alpha\right)\cos\alpha}.$$

A similar expression in which r_1 is written for r_2, and r_2 for r_1, gives the value of A_2.

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The phase angle between the currents A_1 and A_2 is given by

$$\tan(\phi+\psi)=\frac{\left(r_1+\rho\frac{\pi}{2}\right)\left(r_2+\rho\frac{\pi}{2}\right)-\rho^2\left(\frac{\pi}{2}-\alpha\right)^2}{\left(r_1+\rho\frac{\pi}{2}\right)\left(r_2+\rho\frac{\pi}{2}\right)+\rho^2\left(\frac{\pi}{2}-\alpha\right)^2-\frac{\rho\left(\frac{\pi}{2}-\alpha\right)\left(r_1+\rho\frac{\pi}{2}\right)}{\cos\alpha}}\tan\alpha.$$

The expression for ϕ shows that the phase of the current in circuit A_1 is independent of the resistance r_1. On the other hand, varying r_2 alters ϕ. It was also pointed out that tan $(\phi+\psi)$ is generally greater than tan α.

Prof. J. PERRY, F.R.S., read a Paper on "Struts and Tie rods Laterally Loaded."

LEGAL INTELLIGENCE.

Brunton v. Electrical Engineering Corporation.

In the Chancery Division of the High Court of Justice, on Friday, the case of Brunton *v.* Electrical Engineering Company came before Mr. Justice Kekewich in the form of a summons, raising the question whether Mr. Holt had a lien on the books, leases, and papers which, by the direction of his Lordship, he had handed over to the receiver and manager of the Company.

Mr. BRAMWELL DAVIS (with whom was Mr. Renshaw, Q.C.), on behalf of Mr. Holt, said his client claimed a lien on the papers, &c., in respect of costs for work done before the liquidation of the Company. It appeared that in January, 1890, Messrs. Statter and the United Electrical Engineering Company were amalgamated, and called the Electrical Engineering Corporation. Prior to the amalgamation Mr Holt acted for Messrs. Statter, and Messrs. Dowson and Co. were solicitors for the United Company. After the amalgamation Mr. Holt and Messrs. Dowson and Co. were solicitors for the Corporation. A receiver was appointed in March last, and a resolution to wind up the concern was passed on April 23rd. The documents which Mr. Holt had in his possession were the title deeds of freehold and leasehold property, and of the patents purchased. He (the learned counsel) submitted that as solicitor Mr. Holt had a lien on the documents in respect of his costs, and that, therefore, he was entitled to have his costs out of the £270 paid into Court pending the result of the summons.

Mr. WARMINGTON, Q.C., and Mr. SWINFORD EADY opposed the summons, and argued that Mr. Holt had no lien upon the documents.

His LORDSHIP held that Mr. Holt had a lien, and directed that he should have his costs out of the sum which had been paid into Court.

Edison-Swan United Electric Light Company v. Hamilton and Roxburgh.

In the Chancery Division of the High Court of Justice, on Saturday, the case of the Edison-Swan United Electric Light Company *v.* Hamilton and Roxburgh came before Mr. Justice Mathew (sitting for Mr. Justice Stirling). This was an action brought by the plaintiff company against the defendants, Messrs. Hamilton and Roxburgh, of 4B, Newland-terrace, Kensington, for an injunction restraining them from infringing their (plaintiffs') patents and for damages. The defendants did not appear to defend the case, although by their pleadings they had denied the alleged infringement.

Mr. BREMNER opened the case for the plaintiffs, and said the validity of the patents had been upheld in the Court of Appeal. The sole question was one of infringement.

Mr. JOHN MYLES MOFFATT, engineer in the employ of the Edison-Swan United Electric Light Company, stated that on the 4th of May he went to the defendants' shop, No. 4, Newland-terrace, Kensington, and purchased four electric incandescent lamps. On June 3rd he purchased 20 more lamps. He handed the lamps to Mr. Gover, assistant secretary to the plaintiffs' company.

Mr. HENRY CHAS. GOVER, assistant secretary to the Edison Swan Company, stated that he handed the lamps which he received from the previous witness to Dr. Fleming, electrician to the Company.

Dr. J. A. FLEMING stated that he had devoted great attention to electric lighting during the past 14 or 15 years. He had carefully examined the lamps which he received from Mr. Gover. They were composed of a glass reservoir from which the air had been exhausted, and through the walls of the glass reservoir platinum leading wires were sealed in, and to the ends of these wires was attached a filament which upon experiment he found to be carbon. He was well acquainted with the Edison patent, and, in his opinion, the lamps he examined infringed that patent—they contained the four elements of Edison's second lamp. He was also well acquainted with the Cheesbrough patent, which was a special process for testing the filament. The filaments of the lamp he examined had been treated by the Cheesbrough process. He knew the lamps made by the Edison Company, but the lamps produced were not made by that Company.

His LORDSHIP: I think that is enough. You ask, Mr. Bremner, for an injunction restraining the defendants from making any more of these lamps.

Mr. BREMNER: Yes, and for an order for delivery up of all lamps infringing the patent.

His LORDSHIP: Yes; you are entitled to that. You are entitled to an injunction restraining the defendants from further infringement, and for an order for the delivery up of all infringing lamps, and costs.

Mr. BREMNER: I also ask, under Section 29 of the Patents Act, for a certificate that we have proved our breaches.

His LORDSHIP: Yes.

Mr. BREMNER: And under Section 30 of the Act, the validity of the patent having previously been upheld, we are entitled to costs as between solicitor and client.

His LORDSHIP: I don't order them; but if the statute gives them to you, well and good.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December* 5, 1891.

Storage Battery Traction.—A characteristic contribution to the history of storage battery traction comes from the city of Dubuque, Iowa. Two trolley systems were already in operation there when the owners of the only other road in town, which had the marked advantage of a level track, determined to use the storage battery. The route was put in operation during the early part of this year, and at first glowing reports of remarkable success came from it. The outlook continued to be propitious until quite recently, when the Accumulator Company of Philadelphia which furnished the batteries, filed a short time since a suit in the United States courts against the Dubuque Street Railway Company for nearly $50,000; they also, to make assurance doubly sure, filed a similar suit in the Dubuque District Court for the same amount. These actions were to recover payment for the storage batteries used. The defence put in is the old, old story of worthless guarantees; instead of each battery running a year at a cost for renewals of not over $2.50, the Dubuque Company was compelled to renew them every 30, 60 or 90 days. Up to date the expenditure upon them has been 10 times the figure given, and besides that it has been necessary to increase the number of cells per car from 50 to 80. It certainly would seem that however much allowance might be made for *ex parte* evidence the storage battery has been up to its old tricks again, tricks that became familiar in New York several years ago. In the abstract the storage battery is looked upon with favour as furnishing a very pretty solution of the electric traction problem; in the concrete the cost of repairs rises to forbidding magnitude. All this does not deter continued efforts being made; a company with half a million of dollars capital, backed by responsible business men, has recently been organised in New York, for the purpose of developing storage battery traction; and in addition experiments have been instituted in Fort Wayne, Indiana, looking to a new adaptation of the alkaline zincate form of battery for street car work. This latter is under the auspices Mr. M. M. M. Slattery, who has worked over that type of battery for several years and claims to have been one of the first experimenters with it. Between the Waddell-Entz combination and Mr. Slattery this particular form of battery ought to be worked for all there is in it before long.

Government Control of the Telegraph.—Last evening a most interesting discussion was held at the New York Electric Club. The Paper of the evening was on Government Control of Telegraphs, and was read by Mr. E. Rosewater of Omaha, Nebraska. He is a vigorous advocate of Government monopoly; the interests of the members of the Electric Club lie for the most in the opposite direction, and consequently a vigorous discussion ensued, with the usual result,—that is leaving the subject in about its former state. There is a strong feeling in this country that so great an increase of Government patronage would be, under the political conditions at present existing, a source of increased official corruption

City of London Electric Lighting Company.—We are informed that this Company has appointed Mr. David Cook, late Superintending and Consulting Electrical Engineer to the Corporation of Glasgow, as general manager. The supply of current by this Company to private consumers was commenced on Monday last from the Company's central station at Meredith's Wharf. The Mansion House is being supplied with light throughout; and the Company is now prepared to connect consumers on both sides of Queen Victoria-street (eastern end), and expects to be able to connect those in the western end of Queen Victoria-street early in 1892.

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PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *December* 15, 1891.

The new electrical journal, *L'Industrie Électrique*, has now been definitely set on its legs, and the first number will appear on January 1, 1892. *L'Industrie Électrique* has been founded by some thirty persons interested in the electrical industry, who felt the necessity for a serious electrical journal which should keep French electricians *au courant* with what was going on abroad and at home. M. Hospitalier is to be the editor of this new journalistic venture, and he will have the able assistance of M. Gaston Roux. Accuracy and impartiality will, therefore, it may be anticipated, be prominent characteristics of this journal. *L'Industrie Électrique* will differ from the old *Électricien*, over which M. Hospitalier presided so admirably, in being of much the same size and shape as its English contemporaries; it will consequently be in a position to devote ample space to important Papers, and to deal with a variety of subjects in a single issue. It goes without saying that serious obstacles had to be overcome before *L'Industrie Électrique* was definitely inaugurated.

MM. Julien, of Brussels, have taken over the Société Française des Accumulateurs Électriques (E.P.S.) in order to energetically push the sale of accumulators in Paris. This announcement has frequently been made before, but hitherto without much foundation, since the agreement between the two concerns was only signed last week. The action brought against M. Paul Gadot by the Société Française des Accumulateurs came on for hearing on Thursday last. After a few formal proceedings the case was adjourned to January 21st.

M. M. J. J. Heilmann, the inventor of an electrical system of railway working, briefly alluded to in these columns some little time since (see *The Electrician*, Vol. XXVI., p. 586), has succeeded in forming a company with a capital of £12,000 for the purpose of putting his ideas to a practical test. The first electric locomotive on M. Heilmann's system will be at work early in January. The motors, which are placed direct on axles, are of the "polyphase" genus, so that the difficulties inevitable with commutators and brushes are avoided. On the other hand, the firm of Bréguet have just completed an accumulator locomotive for the Chemin de Fer du Nord.

CORRESPONDENCE.

PLATINOID *v.* COPPER FOR D'ARSONVAL GALVANOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As I am responsible for the statement that copper winding makes a given galvanometer 25 times more sensitive than platinoid winding—see extract of discussion, Institution of Electrical Engineers (*The Electrician*, p. 127, 4th inst.)—perhaps you will kindly allow me to make a few remarks to Mr. Mather's interesting contribution on the subject in your last issue.

Mr. Mather opens his argument with the following words: "Although copper has important advantages, where the instrument is only required to measure the *current* passing through it, its large temperature coefficient . . . . &c."

It is shown in the Paper by Captain Sankey and the writer that the two galvanometers belonging to the set of instruments in question must be suitable for a number of measurements, where it is essential that the galvanometer current is small and the resistance fairly low, *e.g.* to calibrate by means of a Clark cell, which frequently has about 1,000 ohms resistance, to measure all kinds of resistances, &c. In order that the platinoid winding shall be suitable for such purposes the d'Arsonval galvanometers must be made at least 20 times as sensitive as those at Thames Ditton, whilst with copper winding these are found sensitive enough for all-round use.

I understood Prof. Ayrton to say that Mr. Mather's improvements had led to increased sensitiveness far beyond the above ratio, and then, in such instruments, of course, platinoid winding is the best. But when Mr. Mather in his letter shows that *with the given instruments* platinoid winding should have been used, then I am afraid he goes too far; for not only would the 10-ohm platinoid coil, which he proposes, be useless for the special purposes referred to, but even for measuring the potential difference at the terminals of the ampere-rheostat it would be a very doubtful improvement, as the following consideration will show.

Mr. Mather says:—"Let no alteration whatever be made in the platinoid sheet used at Thames Ditton to carry the main current, but let the 430-ohm copper coil of the d'Arsonval galvanometer used to measure the potential difference at the terminals of this sheet be replaced by a 10-ohm platinoid coil, the price of which would, of course, be less; then the deflection for a given current passing through the sheet will be increased 25 per cent., and the temperature coefficient reduced to $\frac{1}{15}$th of its value for the copper coil."

It appears that Mr. Mather allows 10 ohms resistance for the suspension; the two coils then compare as follows:—

Current in copper coil for maximum deflection = 66 micro-amperes
,, platinoid coil ,, ,, = 430/20 × 66 = 1,419 ,,
Number of turns in copper coil = N_c
,, ,, ,, platinoid coil = $N_p = 5/4 \times 20/430 N_c = 1/17{\cdot}2N$

Further, as a turn has the same length in either coil and as the ratio of the resistances of the two coils is 42 and the ratio of the specific resistances of the two metals is 25, we shall have:

Cross-section of copper wire = s_c
,, platinoid ,, = $s_p = 1/17{\cdot}2 \times 42 \times 25\, s_c = 61 s_c$
∴ Bulk of metal in copper coil = b_c
,, ,, ,, platinoid ,, = $b_p = 61/17{\cdot}2\, b_c = 3\frac{1}{2}\, b_c$

The platinoid coil thus introduces the following:—

Advantages.	*Disadvantages.*
1. It is (according to Mr. Mather) cheaper than the copper coil.	1. An extra galvanometer must be installed for calibrating and testing work.
2. Twenty-five per cent. increase in the deflection for currents *up to* 30 *amperes*.	2. Twenty-one and a-half times more galvanometer-current than with copper coil, 462 times more heat in each resistance-coil placed in series with galvanometer to measure currents above 30 amperes, errors due to this cause.
	3. Excessive weight of coil.

Finally, as to the temperature coefficient:—This is with the platinoid coil about ·023 per cent. per °C., with the copper coil for currents over 200 amperes (about 8,600 ohms in platinoid coils in series with galvanometer) ·04 per cent. and for currents over 500 amperes (about 17,700 ohms in series) ·0314 per cent.—I am, &c., F. V. ANDERSEN.

December 14, 1891.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Mather in the extreme case he takes, though he debits me (I don't know why) with hanging a ·4-ohm coil with a 10-ohm suspension, forgets that he must credit me with the fact that such 10-ohms suspension is it self-platinoid, so that to stand on the same footing with his 20-ohms total platinoid there would be, with the internal resistance of 9·6-ohm, 49 platinoid to 1 of copper, or a still lower temperature coefficient than I claimed before. If I wanted to employ a ·4-ohm coil I should certainly use the low-resistance suspension, for which, I believe, we have originally to thank Mr. Mather himself and Prof. Ayrton; indeed, my firm is now using them for higher coils as well. To return to the main point: the fact remains that the increased error due to the copper winding *is* only $\frac{1}{80}$ per cent. per degree. Mr. Mather's way of putting it, viz., that the temperature coefficient is 50 per cent. higher only amounts to this—that if he can afford to ignore 3 degrees difference of temperature I can only ignore 2 degrees.—I am, &c., C. W. S. CRAWLEY.

P.S. I see that in Capt. Sankey's Paper the temperature coefficient of his platinoid strips comes out only about ·021.

THE VALUE OF THE "EXTRA CURRENT" ON BREAKING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to call attention to a point in Dr. Fleming's book, "The Alternate Current Transformer," which seems to me to require some explanation. It is, perhaps, rather late

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in the day to raise the question; but as it has, I believe, not yet been discussed, I may perhaps be excused for my delay.

On page 190, while discussing the effect of self-induction at breaking a circuit, Dr. Fleming writes as follows:—"This extra current may have at a particular instant a higher value than that of the strength of the steady current, so that for a short instant the primary current may be actually increased on beginning to break the circuit before it commences to decay." This sentence is apparently founded on the results of some experiments by Blaserna described on pages 196-201. The particular case of the extra current at breaking is described on pages 199 and 200, and on page 201 is a sketch of the curve obtained from this experiment. Here we actually see the current rising above its steady value before it begins to die away. Now surely this extraordinary result must have been produced by some experimental error, for which due correction has not been made. It seems to me pretty obvious that self-induction cannot have caused the current to rise above its steady value, but it may be strictly demonstrated as follows:—

Let E be a constant E.M.F. acting in a circuit of resistance R and inductance L. At a certain time t, after the moment of beginning to break the circuit, let the current be i, and the resistance $R+r$, where r is the resistance of the spark at the break. Let I represent the steady current before breaking,

then $$E - L\frac{di}{dt} = i(R+r),$$

and $$E = IR,$$

subtracting $$-L\frac{di}{dt} = ir - R(I-i).$$

Now if the current i ever rises above the value I, the right-hand side of this equation must be positive and $\frac{di}{dt}$ negative. But it is quite evident that if the current is never rising it can never get higher than I.

It is, of course, impossible to suggest an explanation without a description of the method of interpreting the results of the experiment; but does it not seem possible that the self-induction of the galvanometer (pages 199 and 200) may have interfered with the results?—I am, &c., A. E. Levin.

Plattenstrasse 44, Zürich,
December 5, 1891.

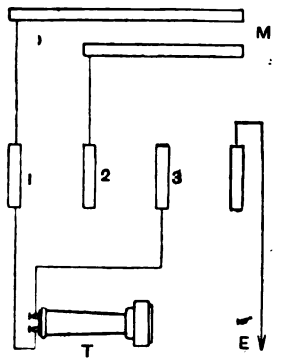
TO THE EDITOR OF THE ELECTRICIAN.

Sir: In brief reply to his criticism on a paragraph and figure in my book on the "Alternate Current Transformer," I beg to thank Mr. Levin for pointing out what is more an ambiguity than an error in one case, but clearly an error in the other. It would require more time than I have at my disposal at this moment to reply fully to Mr. Levin's reasoning in the latter half of his letter; but as regards the paragraph on page 190, a further expansion is evidently necessary to avoid conveying an erroneous notion. This I shall hope to give. With regard to the figure 18 on page 201, this has no essential connection with the former paragraph on page 190, neither does it represent the actual plotting of observations, but was only intended in a very rough way to represent the nature of the oscillations at the commencement and end of the period. The curve at the end ought not, as far as I know, to rise up as it does, but to begin to fall at once. This should, therefore, receive correction, and I am indebted to Mr. Levin for calling attention to it. I may just, however, point out to Mr. Levin that his reasoning in the latter half of his letter would, if correct, not only forbid any rise in the current strength at break, but fail to indicate the possibility of the existence of oscillations at all under any circumstances. These essentially depend upon the existence of capacity somewhere in the circuit, and this is not acknowledged in his equation.—I am, &c., J. A. Fleming.

ON THE TELEPHONING OF GREAT CITIES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: On reading Mr. A. R. Bennett's Paper before the British Association under this title (p. 476, Vol. XXVII., of *The Electrician*) I was struck with the circumstance that it does not appear to have been noticed that the switch shown on page 476 is capable of being considerably simplified. Instead of the nine contacts therein used four only are necessary. If, for instance, the four contacts of the upper row are used, as shown in the accompanying sketch, all that is required is to connect the two conductors (M) to the first two contacts (1 and 2); 4 is connected to earth, and the telephone (T) is placed between 1 and 3. When not in use the telephone switch must then connect 2 and 3, whilst when in use 1 is connected to 2, and 3 to 4.



In the discussion it was further stated that in the Mann system an important improvement had been made by Mr. J. D. Miller in the connections of the so-called service wires. According to the sketches published, these service wires constitute a closed metallic circuit. From this a wire is carried through the apparatus in the exchange to earth, and in every subscriber's room is a terminal of the service wire to which his instrument can be connected when he wishes to call up the exchange. Mr. Miller inquires if such an arrangement, which he arrived at "early in 1887," and which was first applied in Dundee in 1888, had been previously known. I may inform him that in my "Katechisung der Elektrischen Telegraphie," in 1872 and 1882 (fifth edition, p. 265; sixth edition, p. 395), I had briefly described this method for fire alarm work.

An equivalent arrangement, differing only in the use of the earth-line, was patented in Germany on April 25, 1885, by Lewis H. McCullough, and I therefore took occasion to publish in the *Elektrotechnishe Zeitschrift* for 1886, p. 224, a full description of my method, which had then been long well-known, and to make it clear with figures. Mr. Miller explained that he had no knowledge of the previous existence of any such arrangement. He had therefore re-discovered it, and applied it to the service wire in the Mann system. Consequently, he followed the same path as I did myself; for the older arrangement of the service wire in the Mann system mentioned by Mr. Bennett, from which Mr. Miller started, is the equivalent of that so often used for fire alarms (described by me in the *Elektrotechnische Zeitschrift*), and long since served as my own starting-point.—I am, &c.,

Ed. Zetzsche.

TRADE NOTES AND NOTICES.

Tenders Invited.—The Ennis Town Commissioners invite specifications and tenders for the public and private lighting of the town of Ennis by electricity. Such specifications and proposals to be sent to Mr. E. Minikin, Town Clerk, Town Hall, Ennis, by January 1st. All expenses and costs incurred in the preparation of the said specifications and tenders to be borne by the parties sending in same.

Tenders Accepted.—The Liverpool Town Council have accepted the tender of the Liverpool Electric Supply Company (Limited) for laying electric mains to the Walker Art Gallery at £80.

Price List of Dynamos, &c.—Messrs. Charlesworth, Hall and Co., of Oldham, have issued a well-illustrated and fully descriptive list of their manufactures, together with numerous supplies sold by them. The dynamos are, as a rule, Gramme-wound. Numerous arrangements of dynamos are described, *e.g.*, one with a friction clutch, another with a turbine, and several combinations with engines. The projectors supplied by this firm are fully described, and directions for working them are given.

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TENDERS RECEIVED.—At the meeting of the London County Council, on Tuesday, the following tenders were opened for installing the electric light at the central offices, Spring Gardens :—

J. D. F. Andrews and Co.	£1,490	0	0
Barclay and Sons	1,500	0	0
Fowler, Lancaster, and Co. (Limited)	1,564	0	0
J. Jackson	1,570	0	0
H. F. Joel and Co	1,586	0	0
J. R. Powditch and Co.	1,598	0	0
Harry South	1,604	0	0
Croggon and Company (Limited)	1,655	0	0
Drake and Gorham	1,731	0	0
F. G. Howard	1,745	0	0
Woodhouse and Rawson United (Limited)	1,810	0	0
Edmundson's (Limited)	1,815	0	0
London and Lancashire Electric Company	1,825	0	0
General Electric Power Company (Limited)	1,830	0	0
Paterson and Cooper	1,842	0	0
Reid Bros.	1,964	0	0
Electrical Supplies and Fittings Company	1,996	0	0
Mather and Platt	2,000	0	0
Planet Electrical Engineering Company (Limited)	2,056	8	2
Brush Electrical Engineering Company (Limited)	2,136	0	0
Crompton and Co. (Limited)	2,140	0	0
Latimer Clark, Muirhead and Co. (Limited)	2,192	7	0
W. Goolden and Co.	2,229	0	0
Ewart and Son	2,230	0	0
Johnson and Phillips	2,288	0	0
Sharp and Kent	2,300	0	0
Girdlestone and Co. (Limited)	2,300	0	0
Spagnoletti and Crookes	2,590	0	0
Lund Bros. and Co.	2,600	0	0
Siemens Bros. and Co. (Limited)	2,715	0	0
Laurence, Scott and Co. (Limited)	2,815	0	0
Suter and Co.	2,996	0	0

THE MANSION HOUSE.—The installation of the electric light in the Mansion House, which was undertaken by the Planet Electrical Engineering Company (Limited), was completed on Wednesday, when the building was visited by the General Purposes Committee of the Corporation, who expressed their satisfaction with the result.

MESSRS. DRAKE AND GORHAM.—This firm have in hand a complete electric lighting installation for Callarly Castle, which has been recently considerably altered and extended.

PRICE LIST OF CABLES.—Coincident with the reading of Mr. Preece's paper on the Specification of Insulated Conductors, the Telegraph Manufacturing Company, of Helsby, published a new list of cables. The list is arranged with great care, and contains much information. The "specification" of the insulations is given as in the following example :—"Tinned, 1 lap pure Para Rubber, 2 coats vulcanising I.R., 1 I.R. proofed tape. The whole vulcanised, 1 braid tarred, hemp or flax, well compounded." In addition to this, the over-all diameters of the cables are given, but the thickness cannot be directly ascertained. The diameters appear to be identically the same as those of the Silvertown make. Each class is described as offering so many megohms. This sheet is only one of half-a-dozen being issued by the Company, and the special Underground Mains and Concentric Cable Lists will, the Company inform us, contain many of the details suggested in Mr. Preece's Paper. The decrease of the resistance with the size of the conductor is already arranged for in the sheets now issued. It is to be hoped that all makers will revise their lists and re-issue them on one model, giving the information which is really wanted.

THE PHOSPHOR-BRONZE COMPANY.—This Company announce that they have acquired the sole licence for the manufacture of Bull's metals, which they now supply in ingots, billets, castings, forgings, stampings, rolled rods, and sheets. The great malleability, tensile strength, and durability of these alloys render them specially adapted for engineers, ship builders, and others requiring a strong non-corrosive metal of high quality and moderate cost. Mr. J. C. Bull, the inventor and patentee, has joined the Phosphor-Bronze Company as consulting engineer and chemist, and will superintend the manufacture of these alloys at the Company's various works.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

November 19, 1891.

20,141. C. EGGAR. Glasgow. A new or improved system of communicating visible signals and establishing electrical and telephonic connection between central town and district stations, and mechanism and appliances connected therewith.

November 20, 1891.

20,214. W. WHITE. London. Improvements in electropathic appliances.

20,217. J. S. FAIRFAX. London. Improvements in dynamo machines.

November 21, 1891.

20,226. T. B. GRANT. London. Improvements in arc electric lamps.

20,230. J. H. RIDER. Halifax. Improvements in electric arc lamps.

20,247. J. S. YULE and C. K. MARR. Glasgow. Improvements in solenoids, particularly applicable to automatic sound signalling apparatus, but which may also be used for other electrical purposes.

20,257. W. P. THOMPSON. Liverpool. An improved electric arc lamp. (La Compagnie de l'Industrie Electrique, successor and representative of La Société d'Appareillage Electrique, Switzerland.)

20,271. J. C. MORTON. London. A new or improved electric teething neck band for infants.

20,279. G. G. M. HARDINGHAM. London. Improvements in electric cables (The firm of Felter and Guilleaume, Germany).

SPECIFICATIONS PUBLISHED.

1890.

17,863. HARDT. Electric lamps. (Price 8d.)

18,554. PIERCE. Electrical conductors. (Price 8d.)

18,555. PIERCE. Electrical switches. (Price 6d.)

18,557. PIERCE. Electrical switches. (Price 6d.)

18,558. PIERCE. Electrical pendants, &c. (Price 8d.)

19,308. SWINBURNE. Electrical distribution of power by alternating currents. (Price 8d).

20,102. BAXENDALE. Dynamo-electric machines. (Price 6d.)

20,379. BAYLY (Loth). Electric conduit. (Price 8d).

20,896. GAY AND HAMMOND. Regulating electric currents. (Price 11d.)

1891.

40. HOOKHAM. Electricity meters. (Price 8d.)

200. BRIANNE. Electric arc lamps. (Price 8d.)

258. GAY AND HAMMOND. Electric arc lamps. (Price 6d.)

271. SCHOENERSTEDT. Electric arc lamps. (Price 8d.)

389. TEAGUE. Electricity meters. (Price 8d.)

587. BERLYN. Incandescent electric lamps. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

Oxford Electric Company (Limited).

On Saturday last the first ordinary meeting of this Company was held at the offices, 45, Broad-street, Oxford ; J. Irving Courtenay, Esq., Chairman of the Company, presiding.

The notice convening the meeting having been read,

The CHAIRMAN said : This is a formal meeting of the Company, called in compliance with the statute within four months from the incorporation of the Company, and is commonly known as the statutory meeting. There are no accounts to be presented, but the Directors gladly embrace the opportunity thus afforded of explaining the position of the Company, and inviting inquiry and cooperation from the shareholders and others attending the meeting. The Electric Installation and Maintenance Company obtained a Provisional Order, which was confirmed by Parliament on August 4, 1890, under which that Company has powers to supply electricity to the whole borough of Oxford. The Directors being desirous of establishing the business as a local enterprise, have made arrangements for transferring the Parliamentary powers to the Oxford Electric Company (Limited), and the necessary formalities are being carried out for obtaining the consent of the Board of Trade and the Corporation of Oxford to the grant of a Provisional Order for the purpose. In the meantime the Oxford Company having been duly constituted, entered into a contract with the Electric Construction Corporation of London and Wolverhampton, by which the Oxford Company purchases all the rights under the Provisional Order, and provides for the construction of a fully-equipped generating station for the supply of electricity, together with all necessary street works, mains, transformers, and storage batteries, for the supply of an important area which it is first proposed to deal with. This area comprises High-street, Cornmarket-street, Broad-street, Magdalen-street (from the corner of Beaumont-street to Cornmarket-street), and Catherine-street. The area in question, bounded by the streets named, comprises 12 colleges, 39 public buildings and churches, 9 hotels, and 337 shops, offices, and private houses. Provision is made in the contract for a supply of electricity sufficient for about 15,000 lamps actually connected with the Company's mains. The contract provides for the purchase of the lease of the land at Osney, formerly known as Cannon Wharf, the construction of the building, of which drawings may be seen on the walls, the generating and distributing plant, the cost of incorporating this Company and obtaining a transfer of the Provisional Order, a supply of lamps, wire, fittings, &c., to the value of £500, and a sum of £1,500 for the ordinary expenses of the Company. In the contract, the deposit of £1,500 as security paid to the Board of Trade is also provided for, but will be repaid to the contractors on satisfaction of the provisions of the order. Under this contract an agreement has been made for the erection of the generating station with Mr. Kingerlee, the well-known local builder and contractor, who is pushing on the work vigorously, and expects to have all completed by March. During the construction of the building the mains will be laid throughout the compulsory area, so that a supply of electricity will be furnished with all possible speed. The consideration for all these works and payments, including the Provisional Order, is a sum of £50,500, payable in fully paid-up shares of the Company. Assuming the capital expenditure to be

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£50,000, the commercial result of the enterprise may be estimated as follows :—Revenue—258,750 units of electricity, at 8d., and rent of meters, £8,775 ; Expenditure—Running expenses, rent, salaries, insurance, &c., £5,200 ; net income (or 7 per cent. on £50,000), £3,575. The extension of the Company's business to the residential district north of the City and the other important parts of the Borough outside the area comprised in the above calculations, should materially add to the dividends of the Company, as the capital of £50,000 includes building, street works, &c., capable of providing for a larger business. The cost to the consumer at 8d. per Board of Trade unit is equal to about ¼d. per lamp per hour, or, in other words, the current necessary to supply 30 10-c.p. lamps for one hour or their equivalent for a proportionate time. Owing to the facilities for economising the use of electricity by the provision of a sufficient number of switches judiciously placed in the consumer's premises, it is found by experience that, though the relative cost of electricity at 8d. per unit, as compared with gas at 3s. per 1,000 cubic feet, appears to be higher, yet, in actual practice, the amount paid by the householder in each case would not materially differ; but when the convenience and advantages of the electric light, and its indirect economies, such as the saving in renewals of decorations and cleaning of rooms, are taken into account, it is really in the long run cheaper than gas. For a city like Oxford the electric light is almost a necessity. The experience already obtained at the South Kensington Museum and the British Museum proves the value of electricity as a means of illumination for such institutions, while the absolute safety of the method of supply adopted by this Company makes it specially suitable for lighting the various colleges, museums, and public buildings in the City with their priceless contents. I think a few words of explanation are necessary as to the system of electrical supply. I do not propose, however, to go into details, which have been already published, and Mr. Thomas Parker, the chief engineer of the Electric Construction Corporation, who has designed and is carrying out the installation, is here to-day, and will be ready to give any detailed explanation that may be required. The system proposed may be described as a moderate high-tension continuous current of 1,000 volts, with continuous-current transformers to convert to 100 volts, and secondary batteries to supply current to the lamps during the hours of minimum supply, thus allowing the generating station to be shut down entirely. The high-tension continuous current will be conveyed by underground mains, which never come in contact with the houses of the consumers, the electricity delivered to the consumers being absolutely safe, steady, and its continuity secured by the use of the storage batteries. Reliable meters will be supplied to each customer, and charged for by quarterly rental, as in the existing system of gas supply. The cost of fitting premises for the electric light varies with the character of the buildings and the nature of the fittings, which may be of a simple and inexpensive character, or costly designs according to the taste of the consumers. The Company have already been estimating for a few buildings in this City, which may be taken as typical, and comprise—Clarendon Press, 994 16 c.p. lamps, £1,326. 1s. 8d. ; Magdalen College, 675 16 c.p. lamps, £1,433. 18s. ; Christ Church, 595 16 c.p. lamps, £1,190 ; Metropolitan Bank, 45 16 c.p. lamps, £67. 10s. ; Young Men's Christian Association, 62 16 c.p. lamps, £86. 10s. The wiring and fitting of ordinary premises, such as dwelling-houses, shops, and hotels, with simple fittings, can be very well done at the cost of 30s per lamp ; factories and similar buildings at somewhat less ; colleges, museums and similar institutions according to the condition and character of the buildings. All work of this kind is done under stringent rules framed by the Fire Insurance Companies, and controlled also by the provisions for safety contained in the Provisional Order. No other method of artificial illumination can be compared with it for freedom from risk of fire, providing you have suitable fittings and a system of supply such as has been sketched out for the supply of the City of Oxford. As I have already stated, the Company has made its arrangements to carry out all the necessary works without any public issue of capital ; but the intention is, when the preliminary work is completed, to give the public an opportunity of subscribing to the capital, and thus the inhabitants of Oxford will be able to acquire an interest in this important local enterprise.

Mr. T. PARKER then explained matters of detail connected with the proposed system of supply, and incidentally mentioned that Sir William Thomson and Prof. Silvanus Thompson had both recently inspected the electrical plant prepared for this installation and that at Sydenham, and highly approved of the working of the continuous-current transformers, Sir William Thomson having expressed the opinion that their success would lead to the alternating-current system being eventually superseded.

A strong feeling in favour of the introduction of the electric light into the colleges, museums, &c., was very generally expressed, and the prospects of the Company appear to be highly satisfactory.

It was stated that the works were making rapid progress, and that the supply of electricity would be commenced early in the spring.

British Electro-Chemical Agency (Limited).

The first statutory general meeting of this Company was held on Thursday, December 10th, at Worcester House, Walbrook. Mr. Joseph Ebbsmith (the Chairman of the Company) presided.

The SECRETARY (Mr. W. J. Caulfield) having read the notice calling the meeting,

The CHAIRMAN said : Gentlemen, our duties this afternoon will be very brief indeed. As you are aware, this meeting is held in accordance with the provisions of the articles of association—that a general meeting should be called within four months of the registration of the Company, a period which has well-nigh arrived. We do not lay before you any detailed report at this meeting, but it will perhaps be satisfactory for you to learn that the operations of the Company, so far, have more than justified the expectations of the Directors at the time the Company was formed, and when the present shareholders were invited to subscribe. Possibly the results may be of a nature which will be very gratifying indeed to the shareholders, when the general report and balance-sheet are issued. It is proposed to make up our accounts for the financial year to June 30, 1892, but I am at liberty to disclose to you that the affairs of the Company are in such a state that the Directors confidently anticipate their ability to declare a satisfactory interim dividend at the expiration of the six months' working. In reply to inquiries which had been made as to the prospect of calls, I can only say that the power of making calls will be exercised if and whenever the Directors are satisfied that the interests of the Company will be advanced by further share capital, but at the present time there is no prospect of our making any call whatever. We have been fortunate enough already to deal with some of the interests of the Company—what I may, perhaps, term the minor interests of the Company—and we are at the present time in the extremely sound and satisfactory financial position of having our capital intact, and also of having such an increment of profit as appears to be quite sufficient for the immediate requirements of the Company. I shall be very happy to answer any questions which may be asked, but I think I may take it that the remarkably limited attendance of shareholders at the meeting to-day is an evidence that they are satisfied their interests will be safeguarded by the Directors. And although this is essentially a speculative Company, they may be quite sure that the Directors do not intend to incur any unreasonable risks which might prejudice the profits they have already made, and which they have the continued prospect of making.

There being no motion, the meeting closed with a vote of thanks to the Chairman.

The Gulcher (New) Electric Light and Power Company (Limited).

The following report has been issued by the Directors of this Company. The fourth ordinary general meeting will be held at Winchester House, E.C., to-day (Friday), at 12 o'clock :—

The meeting has been called to comply with the Statute, and the Directors intend to move a resolution adjourning the meeting for two months, by which time the Chairman, who is now on his way, will have returned from New Zealand, and will be able to furnish a full report of the results of his visit. The Directors do not propose to submit the usual balance-sheet to the shareholders until the date last mentioned, as the Auditor informs them that it is impossible for him to deal with certain accounts affecting the New Zealand business until these accounts are furnished by the Chairman in a more complete form.

The Directors notify that the Chairman's visit to New Zealand has been entirely successful. During the time he has been out there he has succeeded in obtaining Acts of Parliament for the private lighting of Wellington, Christchurch, and Auckland, and these have passed through both the Upper and Lower Houses of Parliament. He has also concluded a fresh contract with the Corporation of the City of Wellington for the public lighting of that city in lieu of the existing one, and in addition to the contract for the privale lighting, both of which contracts are of a satisfactory character.

Fowler-Waring Cables Company (Limited).

The following is the report of the Directors, to be presented to the shareholders at the third ordinary general meeting, to be held at Winchester House (Hall No. 47), Old Broad-street, London, E.C., to-day (Friday), at 1 p.m. :—

In submitting their second annual report, the Directors express their regret that they are unable to show a profit on the work of the year. At the same time they are glad to say that the business of the Company has made great progress. There has been a marked increase in the volume of business done as compared with last year, and the gross profit has been sufficient to cover all ordinary, and some extraordinary, expenses.

The factory is now well equipped and organised, and the work done there is unsurpassed. Since the close of the financial year numerous orders have been received, to say nothing of many important inquiries. The Directors, therefore, fully retain their previously-expressed confidence in the business, further details of which will be found in the annexed report of the General Manager. There is, however, no manufacturing business in which the competition is keener than it is in ours, and a new undertaking must necessarily require time for development and to make its manufactures known. Meanwhile, as materials must be paid for almost on delivery, and as it is often necessary to give considerable credit to our customers, as well as to provide for special additions to plant to enable us to meet the new demands constantly being made by electrical engineers, the Directors believe that the employment of a larger working capital than the Company possesses would be justified by results and would materially assist in bringing the concern to a dividend paying position. The Directors have again not drawn their fees, but on this occasion they have debited the amount in suspense, as they anticipate a state of things when the payment of this amount will be fully justified by the condition of the business.

The retiring Directors, Mr. Walter Chamberlain and Mr. R. W. Eddison, being eligible, offer themselves for relection. The auditors, Messrs. Cooper Brothers and Co., offer themselves for re-election.

General Manager's Report.

During the past year the Company has made notable progress in each department of its work, and our manufactures have been successfully applied and their efficiency proved in every important branch of electrical engineering. In electric lighting, among the larger orders we have delivered to the London Electric Supply Corporation ten miles of large

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concentric conductors for the distribution of their high-tension currents through the streets of London. These cables are now laid, and are working daily under conditions which demand the most perfect efficiency; the best testimony to their success is the fact that the Corporation have ordered an additional ten miles to be delivered during the next few months. In ship lighting, eight of the new warships at present building for the Admiralty have been wired by cables of our manufacture, and some of the large shipbuilders have adopted them for installation on board the steamships building in their yards. In the electric lighting and transmission of power in mines, the cables have been extensively used, and they contribute very greatly to the success of this difficult and important work. We have also manufactured special wire for use with the explosives employed in blasting and torpedo experiments, and for many more of the ever-increasing number of electrical applications.

In telegraphy, the leading railway companies are adopting lead-covered wires for the tunnels, yards, and stations, and many miles of our cables have been so used during the past year.

In telephony, the Government has employed our cables exclusively for the London end of the Paris telephone lines, and also for connecting up the various centres in London. Large orders have also been entrusted to us by the private telephone companies, and we are at present laying a 100-wire cable through Paris for the French Government telephone service. We have recently despatched fifteen miles of similar cable to Sydney for the Government telephone service there. Only our cables will be employed for the new Central Station at Sydenham, which will supply electric light to the Crystal Palace during the forthcoming Exhibition. Other large orders are in hand, and the prospect of future business is exceedingly good. In my last report I referred to the fact that rubber-covered wires were often specified to the exclusion of all others, and that we deemed it advisable to be prepared to supply these if it became necessary. In many instances we have been able to secure the adoption of our cables in preference to those which are rubber covered, and all the work referred to in this report has been carried out with cables manufactured under those patents and processes which are the exclusive property of the Company.

The works at North Woolwich have never yet been worked to anything approaching their possible output, and consequently we cannot yet show a profit on our work. Sufficient, however, has been done during this year to demonstrate not only the value of our manufactures and the extent and variety of their application, but to justify the firmest confidence in the future of the Company.

The Electric Construction Corporation (Limited)

The following is the report of the Directors of this Corporation to be submitted to the shareholders at the ordinary general meeting, to be held at Cannon-street Hotel, E.C., on Tuesday next, the 22nd inst., at three o'clock:—

In submitting the accounts of the Corporation up to 30th September last, the Directors point out that the period embraced by the previous profit and loss account extended over nearly 16 months, whereas the present report only includes the working at Wolverhampton for one year, and at the Millwall Works for eight months. The Directors are happy to state that the business of the year has been of a satisfactary and promising character, and it will be seen from the accompanying accounts that it has resulted in a profit balance of £46,166. 16s. 8d., from which the Directors have carried £10,000 to reserve for depreciation, leaving a net balance of profit and loss for the year of £36,166. 16s. 8d., which, with the £3,877 11s. 1d. carried forward from last year, makes a total of £40,044. 7s. 9d. available for disposal.

The development of the electro-chemical patents of the Corporation is advancing to the satisfaction of the Directors, and a substantial addition to future profits may be expected from this source. As the shareholders are already aware, Mr. Ebbsmith has resigned his appointment as Managing Director of this Corporation in order to take charge of the British Electro-Chemical Agency (Limited), to which these patents have been transferred: but in order that the Corporation might not be deprived of the benefit of his experience, he has been elected to fill the vacancy on the Board, caused by the lamented death of Sir Robert Fowler.

The Directors have leased the Millwall Works on favourable terms to the Electrical Power Storage Company (Limited), with an exclusive licence to that Company to use the Storage Battery Patents belonging to the Corporation. This arrangement has already proved of great advantage to both parties, and it has the further merit of enabling the manager and chief engineer, Mr. Parker, to concentrate his energies on the important contracts and work which the Wolverhampton Works have in hand.

In continuance of their previous policy, as approved by the shareholders at the last general meeting, the Directors have written off capital expenditure the sum of £20,000 out of the sale of the patents sold or transferred to other Companies during the past year. The sale of these patents will not in any way prejudice the working of the Corporation; on the contrary, it is confidently expected that their development will bring a considerable amount of work to the factory at Wolverhampton.

The Directors have pleasure in recommending a dividend of 6 per cent., payable on January 22nd next, leaving a balance of £10,721. 19s. 4d. to be carried forward to the present year's account. The prospects of business are very satisfactory. The Corporation is at present carrying out, in addition to ordinary work, large and important contracts for the Liverpool Overhead Railway, the Electric Lighting of the City of Oxford, and also for the electrical plant for the Crystal Palace district.

The balance of the authorised debenture issue is now required for the working of the Corporation, and the Directors will be glad to receive applications, as soon as possible, on the form issued with the report, in order to avoid the expense of a public issue.

In conclusion the Directors desire to express their continued and increased confidence in the future of the undertaking.

In accordance with the Articles of Association four of the Directors, viz., Sir Henry Mance, with Messrs. Ebbsmith, Holt, and Moseley, retire from the Board, all of whom are eligible, and offer themselves for re-election. Messrs. Broads, Paterson, and Co., the present auditors of the Corporation, retire, and offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

CALIFORNIA GAS, WATER, AND ELECTRIC LIGHT COMPANY SYNDICATE (LIMITED).—This Company was registered on December 10, 1891, with a capital of £2,000, in £1 shares, by Oldfield, Barham, and Oldfield, St. Stephen's Chambers, Telegraph-street, E.C. The objects are to adopt and carry out agreements for the acquisition of any concessions, rights, or interests relating to gas, water, or electric works, businesses, or concerns in the United States of America, in Canada, and in the Colonies of Great Britain, and to lease or otherwise acquire and carry on such works. The regulations contained in Table A of the First Schedule of the Companies' Acts, 1862, mainly apply. Registered office: 20, Bucklersbury, E.C.

CHLORIDE ELECTRICAL STORAGE SYNDICATE (LIMITED).—This Company was registered on December 12, 1891, with a capital of £262,500, divided into 250,000 Ten per Cent. Preference and 12,500 Founders' shares of £1 each, by the Solicitors to the Company, Hay, Schmettau, and Co., 31, Abchurch-lane, London, E.C. The objects are to adopt a provisional agreement dated November 30, 1891, made between the Electric Storage Battery Company and the United Gas Improvement Company of the one part, and J. A. E. Hickson (for this Company) of the other part, for the sale to the Company of certain patents and other property; to carry on the business of working such patents, and to construct, contract for, establish, carry on, or to finance or provide capital for companies, firms, persons, &c., to enable them to construct, establish, and carry on any works and machinery or apparatus for lighting streets or other places, public and private, by electricity, and for the production, transmission, storage, and use, by any means and for any purpose, of light, heat, electric, magnetic, or other force; to carry on the business of ironmasters, copper smelters, steel makers, iron founders, engineers, boiler-makers, metallurgists, &c.; to carry on the business of an electric light company in all or any of its branches; to construct, lay down, establish, fix, and carry out all necessary cables, wires, accumulators, lamps, and works; and to carry on the business of electricians, electrical engineers, electrical contractors, and suppliers of electricity. The number of Directors shall not be less than three nor more than nine, two of whom shall form a quorum. The first Directors shall be elected by the subscribers, subject to the right reserved to the vendor to nominate one-third of the Board, and until such election, the subscribers shall act as Directors. Qualification: 500 Preference shares. Remuneration: £1,500 per annum divided between them as they themselves determine.

LONDON WARMING AND VENTILATING COMPANY (LIMITED).—Registered by S. F. Taylor, 5, Gray's Inn-square, W.C., with a capital of £10,000, in £1 shares. Object: The acquisition of the undertaking of the London Warming and Ventilating Company, and generally to carry on business as manufacturers of, and dealers in, all kinds of heating, lighting, and ventilating apparatus, electric and otherwise. There shall not be less than three nor more than seven Directors, the first being appointed by the signatories to the Memorandum of Association. Qualification: £50. Remuneration to be determined by the Company in general meeting.

MOUNTAIN'S WIRE MANUFACTURING COMPANY (LIMITED).—This Company was registered on December 10, 1891, with a capital of £25,000, in £5 shares, by Edmonds and Edmonds, 9, Gray's Inn West, W.C. The objects are to take over and carry on the business of nail and brass wire manufacturer, carried on by B. Mountain, at Castleford, Yorkshire; to acquire the whole of the right and title in a British patent, No. 11,429 of 1890, for an invention for improvements in the manufacture of brass and other soft metallic wires; and also the letters patent taken out in France, No. 208,849 of 1890; Belgium, No. 92,303 of 1890; Germany, No. 57,672 of 1890; and the United States of America, No. 372,716 of 1890. The first Directors are W. H. C. Dunhill, W. Fawcett, H. Goodall, J. Horne, and B. Mountain (Managing Director).

NORTHUMBRIAN CHEMICAL COMPANY (LIMITED).—This Company was registered on December 12, 1891, with a capital of £60,000, in £10 shares, by Pattison, Wigg, and Co., 11, Queen Victoria-street, E.C. The objects are to carry on business as manufacturers of chemical products and drugs, of sanitary and disinfectant preparations, manure, soap, &c., and as general merchants and mechanical, chemical, and electrical engineers. The first Directors are J. D. Milburn, W. G. Woods, T. G. Dunford, and J. C. Rollin, all of Newcastle.

COUNTY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The statutory return of this Company, made up to November 30, 1891, was filed on December 7, 1891. The Company was registered on June 30th last, with a capital of £100,000, in £5 shares, to carry on the business of an electric light, heat and power supply company in all or any of its branches. At the date of making up, 200 shares had been taken up, and £1 called upon each. £190 is paid in respect of calls, leaving £10 unpaid. The annual general meeting was held on November 16, 1891. No agreements for the taking over of any business, contracts, or concessions, have been filed. The principal shareholders are the Brush Electrical Engineering Company (Limited), 35 shares, and the Electric and General Investment Company (Limited), 100 shares. Registered office: 1, Great Winchester-street, London, E.C.

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ELECTRICAL ASSETS PURCHASE COMPANY (LIMITED).—The statutory return of this Company, made up to November 23, 1891, was filed on the same day. The Company was registered on July 28, 1891, with a capital of £1,000, in £1 shares, to take over the business and assets of the Liepmann Carbon Company (Limited). 564 shares have been taken up, 500 of which have been issued as fully paid to the Liepmann Carbon Company (Limited), in pursuance of an agreement made November 5, 1891 (filed on the 12th following). Upon the remaining 64 the full amount has been called and paid. Registered office: Eastcheap Buildings, 19, Eastcheap, E.C.

ELECTRICAL FINANCE CORPORATION (LIMITED).—Memorandum of agreement made December 8, 1891 (filed on the 11th), between William Martin, of No. 12, Poplar-grove, Shepherd's Bush, in the County of Middlesex, gentleman, of the one part, and Charles Edmund Baker, of No. 22, Great George-street, in the City of Westminster, as trustee for and on behalf of a Company registered in the name of the Electrical Finance Corporation (Limited), of the other part, whereby it is agreed as follows:—(1) The said William Martin shall provide by himself or his friends the money necessary for registering the above-named Company, and pay the expense of preparing and printing the Memorandum and Articles of Association of the Company and the preparation of the prospectus. (2) In consideration therefore the said C. E. Baker doth, at the request of the said W. Martin, hereby agree, on behalf of the Company, that the first 50 Founders' shares, numbered 1 to 50 inclusive, shall be allotted as fully paid to the said William Martin or his nominees. This Company was registered on November 18th last, with a nominal capital of £100,000, divided into 19,800 ordinary and 200 Founders' shares of £5 each.

ELECTRIC LIGHTING COMPANY (LIMITED).—The following notices were filed on December 8, 1891:—"In the matter of the Companies Acts, 1862 to 1890, and in the matter of the Electric Lighting Company (Limited). To the Registrar of Joint Stock Companies, Somerset House, W.C. Dear Sir,—I beg to inform you that a general meeting of the above-named Company was held at my offices, No. 1, Queen Victoria-street, in the City of London, on Thursday, November 26th last, in accordance with Section 142 of the Companies Act, 1862, at which meeting an account was submitted, showing the manner in which the winding-up has been conducted, and the property of the Company disposed of. Minutes of the proceedings at such meeting are sent forthwith. Your obedient servant, ROBERT A. MCLEAN, liquidator." The liquidator reported that the Company was formed, as the shareholders were aware, in the early days of electric lighting, for the purpose of working what was then known as Wilde's process. The entire capital of the Company was supplied by the signatories to the Memorandum and Articles of Association, and their operations were in the nature of an experiment to ascertain, at their own cost and risk, whether the process was likely to be commercially successful before inviting the public to subscribe. The greater part of the capital was paid to Mr. Wilde for the use of his process, and the rest was expended in numerous experiments and trials at the South Kensington Museum, the Polytechnic, the Gaiety Theatre, and elsewhere, the result being, after eight months of labour, that the Company came to the conclusion that the process was not likely to be a success, and resolved to liquidate. The above-named Company was registered on October 5, 1878, with a capital of £100,000, in £10 shares. The signatories were:—Baron Emile Erlanger, of 43, Lothbury, 225 shares; R. J. Hood, 10; Sir Philip Rose, 10; J. Hollingshead, 10; Lionel Lawson, 225; C. F. de K. Steuart, 10; and R. A. McLean, 10, making a total of 500 £10 shares taken up. No further returns have been filed.

"ENERGY" GAS, ELECTRIC LIGHTING AND POWER COMPANY (LIMITED).—The statutory return of the above-named Company, made up to December 10, 1891, was filed on the same day. The Company was registered on August 1, 1891, with a nominal capital of £20,000, in £1 shares. Seven shares only have been taken up, upon which nothing has been called, the original subscribers being the only shareholders. Registered office: 5, Chancery-lane, London, W.C.

EPSTEIN ELECTRIC ACCUMULATOR COMPANY (LIMITED).—The statutory return of this Company, made up to December 1, 1891, was filed on the 10th following. The Company was registered on July 31, 1891, with a capital of £101,000, divided into 100,000 ordinary and 1,000 founders' shares of £1 each, to acquire the patents and patent rights of Mr. Ludwig Epstein, relating to the invention of improvements in the manufacture and use of secondary or storage batteries, and to work the same. An agreement made July 31, 1891, between Woodhouse and Rawson United (Limited), of the first part, L. Epstein of the second part, and this Company of the third part, stated that it was agreed that L. Epstein should be Managing Director, with a remuneration of £100 per annum, and 10 per cent. of all net profits, except those made from the sale of patents or the sale or granting of licences. It was also agreed that in respect of the purchase of the patents £31,500 in fully paid ordinary shares, and £450 in fully paid founders' shares should be paid to L. Epstein, and that £38,700 in fully paid ordinary and £550 in fully paid founders' shares should be paid to Woodhouse and Rawson United (Limited). The patents sold to the Company are:—England, Nos. 3,770 of 1882, 9,195 of 1884, 4,527 of 1887, and 350 of 1890; France, Nos. 162,730 of 1884, 182,219 of 1887, and 205,218 of 1890; Belgium, Nos. 65,464 of 1884, 76,744 of 1887, 78,705 of 1887, and 90,289 of 1890; United States of America, Nos. 382,420 and 383,216 of 1888, and 425,999 of 1890; Italy, Nos. 17,060 and 77 of 1884, 21,406 and 362 of 1887, and 27,352 and 420 of 1890; Cape of Good Hope, No. 664 of 1891; South Australia, No. 1,854 of 1891; India, No. 47 of 1891; New South Wales, No. 2,802 of 1891; and Victoria, No. 8,494 of 1891. Patents applied for in Canada, Sweden, Queensland, New Zealand, and Spain are included. At the date of the making up all the founders' and 70,207 of the ordinary shares were taken up, and upon 200 ordinary 5s. per share had been called and paid. The remaining 1,000 founders' and 70,007 ordinary shares were issued as fully paid. The working capital of this Company appears by the above statement to be very small, but this is supplemented by a loan of £7,500, bearing interest at 5 per cent. per annum from Woodhouse and Rawson United (Limited). Registered office: 34, Cannon-street, London, E.C.

INTERNATIONAL ELECTRIC SUBWAY COMPANY (LIMITED).—An agreement dated December 3, 1891 (and filed December 12th), between W. H. Johnstone, of Philadelphia, U.S.A., electrical engineer, and F. W. Toppan (called the vendors) of the one part, and the above-named Company of the other part, states that, whereas by an agreement dated November 23, 1891 between the same parties, it was agreed that the vendors should sell and the Company should buy certain letters patent, and that as part of the consideration for the said sale the Company should issue to the vendors or their nominees 5,000 £1 shares, fully paid, it is hereby agreed that on the completion of the said sale the Company shall issue the said shares, numbered 8 to 5,007 inclusive, to the vendors or their nominees, in full satisfaction of that portion of the purchase money which was to be satisfied by the allotment of fully paid shares. Another agreement of the same date and between the same parties states that, whereas it was agreed that certain patents and other property should be sold to the Company, it was now agreed that the vendors should accept the allotment of 15,000 fully paid £1 shares in the purchasing Company in full satisfaction of that portion of the purchase money, which was to be satisfied by the allotment of paid-up shares. Offices: 43, Threadneedle street, London, E.C.

ITALIAN ELECTRICAL LIGHT AND POWER COMPANY (LIMITED).—The statutory return of this company, made up to November 30, 1891, was filed on December 7th following. The nominal capital is £60,000, in £4 shares. The Company was registered on July 17th last, to carry on the business of an electric light, heat, and power supply company in all or any of its branches, and particularly to enter into an agreement, dated July 18, 1891 (filed on the same day), between the Cavalieri Girolomo Taddei, of 83, Via Avenula, Rome, civil engineer, and this Company, for the sale to the Company of three electrical installations in Italy, and which states that, in full consideration for such installations, Girolomo Taddei agrees to accept 1,743 fully-paid £4 shares, numbered 8 to 1,750 inclusive, to be allotted either to him or his nominees. At the date of the making-up 307 shares were taken up, 300 of which had been issued to Girolomo Taddei as fully paid. Upon the remaining 7 nothing has been called. The original subscribers are at present the only shareholders. Registered office: 10, Austin-friars, London, E.C.

VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY (LIMITED).—The annual return of this Company, made up to December 4, 1891, was filed on December 11th following. The Company was registered on April 22, 1890, with a nominal capital of £70,000, in £1 shares. All the shares have been taken up, and upon 13,494 the full amount has been called and paid. The remaining 56,506 were issued as fully paid. The principal shareholders are Messrs. Westendorp and Co., bankers, of Amsterdam (1,500 shares); Paul Bevez, of 21, Avenue Montaigne, Paris (3,000); Sir Douglas Fox, of Coombe Springs, Kingston-on-Thames (2,500); Messrs. G. Blancke, Zoon, and Co., bankers, of Amsterdam (56,056); and J. Balli, of 20, Great Winchester-street, E.C. (4,000). Registered office: 37, Lombard-street, London, E.C.

WOLVERHAMPTON ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 18, 1891, was filed on December 10, 1891. The Company was registered on June 18, 1889, with a capital of £50,000, in £10 shares. 23 shares only have been taken up, the full amount has been called upon each, and all calls paid. No agreements for the taking over of any businesses, concessions, contracts, or plant have been filed, and all shares are taken up locally. Registered office: Wolverhampton.

CITY NOTES, &c.

BRIGHTON AND HOVE ELECTRIC LIGHT COMPANY (LIMITED).—The prospectus of this Company will be found in our advertising columns. The Company is registered with a capital of £100,000, in 20,000 shares of £5 each, of which £15,000 has already been issued and is fully paid up. The present issue is for £15,000 First Mortgage Debentures in 150 Six per Cent. Debentures of £100 each, repayable at par on January 1, 1895, or earlier, at the Company's option, at £105, interest payable half-yearly in January and July of each year. £12,500 is the balance remaining for issue, and the Company is prepared to receive application for the amount at par. Payable, £10 on application, £15 on allotment, £25 on February 1st, £25 on March 1st, and £25 on April 1, 1892. The capital asked for in the present issue is required, the prospectus states, to enable the Company to deal with the large increase of business which is springing up. The Company owns the Central Station at Brighton, which has been supplying that town with electricity since 1882, which was only taken over by the Brighton and Hove Company in November, 1885, and the following dividends have been declared since that time:—1886, 4 per cent.; 1887, 1888, 1890, 5 per cent. each year. The Company's lighting area is about 14 miles in extent, and the mains tap the most eligible portion of Brighton and Hove. The bankers of the Company are the London and County Bank (Limited), Brighton, and the lists of applications will close to-morrow (Saturday), the 19th inst.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts of this Company for the week ended December 16th amounted to £815; aggregate receipts for half-year to date, £17,568.

CROMPTON AND CO. (LIMITED).—The Directors of this Company have declared an interim dividend at the rate of 7 per cent. per annum on

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the preference shares, and 5 per cent. per annum on the ordinary shares, for the half-year ended 30th September last.

EASTERN EXTENSION TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend for the quarter ended September 30 last of 2s. 6d. per share, free of income-tax, payable on January 15 next.—This company notify that the coupon on the Five per Cent. Australian Government Subsidy Debentures, due on January 1st next, will be payable on and after that date at Messrs. Barclay, Bevan, and Co.'s, 54, Lombard-street, E.C. Coupons must be left three clear days for examination.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY.—This Company notify that the coupons due on January 1, 1892, on their Five per Cent. Mortgage Debentures will be paid on and after that date at the banking house of Messrs. Barclay, Bevan, and Co., 54, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—This Corporation invite applications for the balance of their Six per Cent. First Mortgage Debentures of £100 each. Forms of application may be obtained of the bankers of the Corporation, Messrs. Prescott, Dimsdale, Cave, Tugwell, and Co. (Limited); or at the office, Worcester House, Walbrook, E.C.

EUROPEAN SIMS-EDISON ELECTRICAL TORPEDO COMPANY (LIMITED).—Major-General E. Harding Steward has joined the Board.

ST. JAMES AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED). It is announced that the 10,000 new £5 preference shares recently offered to the shareholders of this Company were allotted on the 11th inst. at £1 10s. premium.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The coupons due December 31st on the debentures of the West Coast of America Telegraph Company (Limited) will be paid by Messrs. Barclay and Co., Lombard-street. The coupons must be left three clear days for examination.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Dec. 9		Price Wednesday, Dec. 16.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Dec. 16.	
										Highest.	Lowest.
			TELEGRAPHS.					£ s. d.			
£1,300,980	Stock	12/6	Anglo-American	49	50	50	51	5 3 0	Jan., Apr., July, Oct.	50⅝	49⅞
£2,849,510	Stock	25/0	Do. Preferred	87½	88½	88	89	5 18 0	" "	88⅝	88
£2,849,510	Stock	5/0	Do. Deferred	12¼	12⅝	13	13½	..	" "	13¼	13
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	102¼	102
130,000	£10	5/0	Brazilian Submarine	11	11½	11	11½	7 2 3	Mar., June, Oct., Dec.	11⅜	..
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	101	104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	104	108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	145	148	145	148	4 14 7	April and October	150⅜	149½
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	10¾	..
6,000	10	10%	Do. Preference 10%	16	17	16	17	5 17 8	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½	3¾	3½	3¾	6 18 8	April and October	..	..
6,000	5	10%	Do. Preference 10%	9½	10½	9½	10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10¾	11	10⅞	11⅛	6 6 2	Jan., Apr., July, Oct	11⅛	10⅞
140,000	10	2/6	Eastern	14	14½	14	14½	4 11 3	" "	14½	14
70,000	10	6%	Do. 6 per Cent. Preference	14½	15½	14⅝	15½	3 18 8	" "	15½	14⅞
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	107⅜	106⅝
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	108¼	..
250,000	10	2/6	Eastern Extension	15	15½	15	15½	4 12 7	Jan., Apr., July, Oct.	15 3/16	14⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107	110	107	110	3 12 9	February & August	109½	109
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	102	105	103	106	4 14 4	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1900 (regd.)	98	101	99	102	3 18 5	February and August	100¾	..
180,227	10	2/0	Globe Telegraph and Trust	9⅝	9⅞	9⅝	10	5 7 6	Jan., Apr., July, Oct.	10	9 11/16
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15	14⅜	15	4 0 0	" "	15	14 13/16
100,000	10	5/0	Great Northern	18⅜	19½	18⅜	19½	4 8 4	Jan., April, and July	19½	18⅞
£ 90,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	107½	105½
9,000	8	4/0	Reuter's	7⅜	8¼	7⅜	8¼	4 16 11	April and October	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	115	120	117	122	4 18 4	" "	116	..
15,609	10	6/0	West African Telegraph	7½	8½	7	8	6 5 0	January and July	7	..
£271,400	100	5%	Do. 5 per Cent. Debentures	97	100	97	100	5 0 0	March & September	..	..
30,000	10	2/0	West Coast of America	3½	4½	3½	4½	..	January and July	4	..
£150,000	100	8%	Do. Debentures 8% 1902	99	104	100	105	7 12 5	June and December	..	..
88,321	10	1/0	West India and Panama	1½	1⅝	1½	1⅝	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	8⅝	9½	8⅝	9½	6 9 0	May and November	9⅝	9
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7	8	7	8	7 10 0	" "	..	..
67,007	15	6/0	Western and Brazilian	10½	10⅝	10½	10⅝	6 19 5	" "	10⅝	10½
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6½	6⅝	6½	6⅝	5 7 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4	4½	4	4½	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜	½	⅜	½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16	1/16	1/16	1/16	6 3 11	Yearly	½	..
438,984	5	2/6	National xd	4⅜	4⅝	4½	4⅝	6 13 4	June and December	4⅝	4½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref. xd	12½	13	12½	12⅝	4 14 1	" "	12⅝	12⅛
15,000	10	6%	Do 6% Cumulative 2nd Prf. xd	12	13	12	12½	4 16 0	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	107	109	107	109	4 2 7	January and July	108¼	107½
58,000	5	1/0	United River Plate	1	2	1	2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£6 paid)	4½	5½	5½	6	..	..	..	..
13,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
8,332	£5	..	House to House Electric	4½	5	4½	5	..	..	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2¾	2⅞	2¾	2⅞	..	..	..	..
10,000	£5	3½%	Do. (fully paid)	4⅞	5⅛	4⅞	5⅛	..	..	..	..
111,000	5	..	London Electric Supply	1⅛	1⅜	1	1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9¾	10¼	9¾	10¼	..	..	10⅝	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	6½	7½	6½	7½	..	..	..	..
18,680	£5	3/6	St. James' and Pall Mall	8¾	9¼	8¾	9¼	..	..	..	..
7,900	£5	7%	Do. 7% Preference	7¼	7¾	7¼	7¾	..	..	7⅞	..
42,853	5	..	Westminster Electric Supply (£5 paid)	6¼	6¾	6¼	6¾	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/8	Brush Electrical Engineering	3¼	3½	3⅛	3⅜	..	..	3 1/16	3⅛
69,996	2	6%	Do. 6 per Cent. Preference	2	2¼	2	2¼	5 6 8	..	2¼	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼	5¾	5½	6	5 16 8	January and July	5 1/16	5⅝
17,130	5	17%	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	6%	Electric Construction	6	7	6½	7	..	—	7	6½
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅞	3⅛	1⅞	2⅛	..	—	3	2⅛
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20½	21½	20½	21½	4 15 3	February and August	21⅛	20⅞
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	5	6	4	5	..	..	..	..
11,334	£10	8/0	Do. Preference	8⅞	9½	8⅞	9½	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅞	⅞	⅞	⅞	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	4½	4⅝	4½	4⅝	8 2 0	May and November	4 1/16	..
36,250	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July	..	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2⅛	2⅜	2⅛	2⅜	15 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	3⅜	3⅝	2⅝	2⅝	..	—	..	..
			RAILWAYS AND TRAMAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	—	—	—	—	—	—
50,000	£10	—	City and South London Railway	3	5	—	5	—	—	—	—

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NOTES.

The preliminary steps which have been and are being taken in connection with the proposed International Electrical Congress to be held at Chicago in 1893 have given rise to a somewhat heated dispute. In Chicago some talk of "unparalleled audacity," coupled with "effrontery," and "impudent and snobbish editorials," and New York retorts with allegations of "high-handed indifference." "The very head and front of offending" has been the appointment of Prof. Gray and a posse of Chicago electrical celebrities (to the complete exclusion of the members of the American Institute of Electrical Engineers) to set the Congressional machinery in motion. The Federal Government is much to be pitied. In its endeavours to please everyone it satisfies nobody, and with the ever latent jealousy between New York and Chicago fully aroused every appointment is a signal for a recriminatory chorus. The Exhibition is, however, eighteen months distant, and we make no doubt that by May, 1893, the present storm in a tea-cup will have subsided, and a satisfactory compromise have been effected.

The proposed International Electrical Congress is perhaps the most promising international feature of the whole Exhibition. By the summer of '93 there will be several matters connected with nomenclature, units and definition awaiting imprimatur; and what soil more appropriate than that of America on which to formally admit the names of Franklin and Henry into the electrical Temple of Fame. The Chicago Exhibition will have been justified, if it be the occasion of the holding of a truly representative International Electrical Congress, which confines itself to its proper work and avoids farcical discussions in half-a-dozen tongues on subjects outside its jurisdiction.

At the meeting of the Physical Society on Friday last, an interesting discussion arose as to the exact meaning properly or generally conveyed by the word *inductance*. One of a numerous and useful class of words suggested by Mr. Heaviside in his articles on electro-magnetism published in *The Electrician*, some years ago, this expression has proved so handy and appropriate that it has come into common use, but apparently it is employed in two senses. Some use it as a shorter and more convenient term for L, the coefficient of self-induction, while others employ it to represent the value of $2\pi n$ L, where n is the frequency of the current in periods per second. In the theoretical investigation of alternate currents it rarely happens that the coefficient L appears in the formulæ except in company with the multiplier $2\pi n$; so that it would appear more convenient to use the word *inductance* to represent the whole expression $2\pi n$ L rather than L alone. On the other hand, the expression *coefficient of self-induction* is so cumbrous as to render a briefer term desirable, and the convenience of the word *inductance* is sometimes shown by its use in both senses by the same writer. Mr. Heaviside originally introduced the word to represent L alone, but it has perhaps been more generally used to denote $2\pi n$ L than L, and an advantage of this arrangement is the simple relation which then obtains between resistance, inductance, and impedance. These three important quantities are then each measured in ohms, and their magnitudes are always represented by the sides of a right-angled triangle, impedance being denoted by the length of the hypotenuse. The word inductance is one which has come to stay, and it is therefore desirable to fix its meaning as soon as possible and to choose that meaning which will render it most useful.

The induction coil has at various times formed the subject of much important work. The early researches of Blaserna, Bernstein, and Helmholtz were carried out when electricians were much less familiar than they are at present with the character of electric oscillations; yet these investigations clearly showed the wavy nature of the currents in the coils at the moment of making or breaking the primary circuit, and our readers will find an excellent description of them from the pen of Dr. Fleming, in *The Electrician* for December 28, 1888, and for January 4, 1889. After the great work of Hertz had focussed the attention of scientific men on the subject of electro-magnetic waves, it occurred to Dr. Fleming that the action of the condenser in an induction coil was such as to form essentially a resonance phenomenon. His views were explained in an article printed in our issue for May 31, 1889, and were afterwards criticised in our columns by Mr. C. V. Boys and Dr. Lodge. Any one interested in the theory of the induction coil cannot do better than refer to these articles, as the subject is treated from three distinct points of view, while the conclusions arrived at are very similar. In the present issue also we print an interesting article by M. Colley, which will be found worthy of study in connection with those just referred to. The subject is treated chiefly

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from the experimental side, and the investigation brings out prominently the effect on the character of the discharge, produced by variations in the capacity of the condenser employed, and in the self-induction of the primary and secondary circuits.

Central London Railway.—The preliminary borings for the Central London Railway reveal satisfactory conditions.

Huddersfield.—At a meeting of the Huddersfield County Council on Wednesday, Mr. W. C. Mountain, of Newcastle-on-Tyne, was appointed electrical engineer, at a salary of £200.

The Specification of Insulated Conductors.—On page 161 of our last issue, for $\sigma = R' l \times \frac{d+t}{t}$ read $\sigma = R' l \pi \times \frac{d+t}{t}$.

Rathite.—Rathite is a new insulating compound, composed of vulcanised india-rubber and silk fibre. The idea is to apply this form of insulation in all cases where solidity rather than flexibility is wanted. The compound is due to MM. Waddington, Rath et Cie.

The City and Guilds of London Institute.—On the motion of Mr. Shaw, seconded by Mr. A. A. Wood, it was resolved at the last meeting of the Common Council to instruct the Coal and Corn and Finance Committee to consider the present position of the above Institute, and to report their opinion thereon.

Inter-urban Telephony in Spain.—No tender having been presented to establish the direct telephone lines between Madrid and the important provincial towns of Cordova, Seville, and Cadiz, the Spanish Government, says *Industries*, has decided to establish those lines as a national service, and the erection will be proceeded with at once.

The Ardois System of Electric Night Signals.—The U. S. cruiser "New York," which was launched on the 2nd inst., is to have a most elaborate electric plant. The Ardois system of electric night signals is to be used. This system was briefly described in *The Electrician* some little time ago, and consists of yard-arm lanterns permitting 62 combinations from a key-board.

Puebla.—The town of Puebla (Mexico) has now to be added to the already long list of towns which are actually obtaining, or seriously proposing to obtain, electric energy from a distant source. The generating plant comprises three 50-H.P. 2,200-volt alternators, driven by turbines. The motive power is a 33ft. waterfall, capable of giving 600 H.P., and situated six miles from the centre of the town.

Terrestrial Magnetism.—Terrestrial magnetism and solar physics, in their relation to meteorology, is to be made the work of a special department in the Weather Bureau. Prof. Frank H. Bigelow, late assistant in the *Nautical Almanack* office, will be in charge. Prof. Bigelow's recent discoveries regarding the solar corona and terrestrial magnetism, says *Engineering News*, especially fit him for this post.

Dielectric Constants.—In a Paper read at a recent meeting of the Académie des Sciences, M. Lefebvre stated that he had determined the following dielectric constants:—Sulphur, flower and roll, 2·6; sulphur, cast in rolls six months previously, 3·9; ice, different specimens, 3·45 and 2·4; ebonite, 2·3; paraffin, brown, 2·1; white ditto, 2·0; petroleum, 1·9; carbon bisulphide, 1·7; spirits of turpentine, 1·5.

A New American Engineering Firm.—The *Electrical World* announces that Mr. Frank J. Sprague, Dr. Louis Duncan and Dr. Cary T. Hutchinson have combined their energies, and will enter the field of general electrical engineering under the firm name of Sprague, Duncan and Hutchinson, with offices at 15, Wall-street. The new firm propose to do a consulting and supervising business without personally undertaking contracts.

Electric Mining Lecture.—There was a large attendance of members of the Midland Counties branches of the National Association of Colliery Managers in the large Lecture Theatre of Nottingham University College, on Saturday last, to hear Prof. Robinson deliver one of the series of lectures arranged for by the Association and the Technical Education Committees of the Notts and Derbyshire County Councils. Prof. Robinson took for his subject "Electricity as Applied to Mining."

Calcutta.—The Calcutta Municipal Commissioners have decided to light the New Central Road by electricity. The Howrah Bridge has now been lighted by electricity for several months with complete success. The road, which is now completed, except one short section, will be nearly two miles long. It is expected, says the *Indian Engineer*, that the lights will be ready to work soon after the last section of the road is finished, which will be in the course of this cold weather.

Primary Battery Competition.—Our Milan contemporary, *L'Elettricita*, announces an international competition for a prize of £80, to be awarded to the inventor of a new, practical, simple, and commercial battery. The competition will remain open from January 1, 1892, until August 31st of the same year. The jury, we are told, will be composed of competent and estimable individuals. Further particulars may be obtained from the editor of *L'Elettricita*, 2, Via Meravigli, Milan.

Glow-Lamp Stealing.—For some time past the incandescent lamps at the Paris Theatres have been the object of the polite attentions of a thief, who has just been arrested by a clever device of the management of the Porte St. Martin. As it was found that a great many lamps had disappeared at that house, the electrical engineer so arranged matters that immediately a lamp was removed an alarm was sounded. The man was thus caught as he was making away with the lamp in his pocket. It is believed that he has a large store of stolen lamps.

Electric Lighting in Chelsea.—During 1890 some 100 houses adopted electric lighting in Chelsea. At the end of February last the number of houses lighted by the several companies was:—

	1889-90.	1890-91.
Chelsea Electricity Supply Company ...	113	215
Cadogan Electric Light Company	25	16
London Electric Supply Corporation ...	1	2
	139	233

The Artesian Well in the City.—At a recent meeting of the Commissioners of Sewers, the Engineer reported upon the artesian well which the Commissioners are sinking at the artisans' dwellings in the Minories. He stated that the well had been bored to an additional depth of 100ft., making 450ft. in all; the average daily yield being 50,000 gallons. He recommended that the boring should be continued for another 100ft. It was ultimately decided to sink the well an additional 200ft.

Secondary Batteries.—Commenting on Prof. Armstrong's recent remarks at the Society of Arts, that secondary batteries should be discussed by chemists rather than electricians, *Industries* says, "As electricians have probably more all-round capacity than chemists, it is probable, in spite of Prof. Armstrong, that a pure chemist will do as little as a pure electrician. What is required to study electrolysis successfully is a thorough knowledge of the specialised chemistry needed, and also of electricity and thermo-dynamics. An acquaintance with thermo-dynamics is most essential."

Electric Lighting in Johannesburg.—The Johannesburg *Star* of November 14th contains an interesting account of the electric lighting of the Standard Theatre in that city, and refers to the general adoption of the electric light in Johannesburg. Numerous companies along the Reef have put down electric lighting plants, and a number of private firms have also adopted the electric light. The Standard Theatre installation was superintended by Mr. Sanders, chief of the Electrical and General Engineering Syndicate, who has had considerable experience in the lighting of the Crystal Palace in England.

Breaking Strength of Glass.—Mr. G. W. Plympton, M. Am. Soc. C. E., says the *Engineering and Mining Journal* of New York, has recently made a number of experiments on the breaking strength of glass. The glass used was of Dutch manufacture and varied from ·290in. to ·345in. in thickness; strips of the glass 2in. wide were supported on uprights 18in. apart and loaded at the centre. The bars deflected regularly

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up to the breaking load, giving no indication of an elastic limit. Applying the formula, breaking load $= \frac{cb\,d^2}{e}$, the average value of the coefficient c was about 3,300lb.

Our Postal Telegraphs.—Some 21 pages of *The Engineer* of December 18th are devoted to an elaborate illustrated account of the Central Telegraph office. "The postal telegraph system of Great Britain and Ireland," says our esteemed contemporary, "is now the most gigantic and complete organisation for the transmission of messages in the world. . . Millions of individuals make use of it, yet a very few outside a small circle possess an adequate acquaintance with the methods and machinery by which so large a portion of the world's work is done." To fill up this vacuum of ignorance is the purpose of our contemporary's most interesting "special number."

The Leeds Electric Tramway.—One of the most severe fogs which has been experienced in the Leeds district for years prevailed there on Monday. A somewhat serious accident on the Roundhay Park Electric Tramway is reported. A car was standing in Harehills-road, where the fog was extremely dense, when another car came along the same line, causing a violent collision. On the stationary car the driver was standing; but, fortunately, there were no passengers. The front of the vehicle was badly smashed. The moving car was only very slightly damaged, and it was about an hour and a-half before the traffic could be resumed, the line being strewn with *débris*.

Electrical Analysis of Milk.—A method for determining the quality of milk by ascertaining its electrical resistance is described in a recent number of the *Chemiker Zeitung*. The idea underlying the process was, in the first place, that a rise in resistance might be expected with increase of fat, and a similar augmentation follow on dilution with water. After the execution of some scores of experiments it was found that an important factor in the fluctuations observed consisted in the nature and quantity of inorganic salts present in the water used for dilution. In order, therefore, to get even approximate accuracy, it is necessary to know the nature and source of the diluent.

Three-Phase Currents and the Telephone Lines.—According to the *Neue Tageblatt* (Stuttgart), the working of the telephone lines between Stuttgart and Heilbronn was considerably interfered with by the experiments carried on on the three phase line between Lauffen and Frankfort after the close of the Exhibition. From tests carried on with the Lahmeyer system at Offenbach, it would appear, however, that the rotary current is much less objectionable in this respect than an alternating current. In this case a telephone line was carried parallel to the rotary current lines and within one yard of them for a distance of six miles, and it was found that conversation could easily be carried on whilst 600 glow lamps were being run off the rotary-current leads.

Belt Formula.—At a recent meeting of the Engineers' Club of Philadelphia, Mr. B. H. Coffey gave the following formula for the horse-power of a driving rope: 1. Neglecting centrifugal force,

$$\text{H.P.} = \frac{V(D^2 + D - 1)}{280},$$

where V = velocity of rope in feet per minute, and D = diameter of rope in inches. 2. Allowing for centrifugal force,

$$\text{H.P.} = V\left\{\frac{2700\,A - W\,V^2}{11{,}180}\right\},$$

where $A = (D^2 + D - 1)$

V = velocity of rope in feet per second, and

W = weight in pounds of rope per foot.

A Surgeon's Transformer.—A handy transformer for surgical purposes has been devised by Dr. Arnold B. Woakes, surgeon to the London Throat Hospital. It is designed to transform an alternating or varying current so as to light a small glow lamp for examinations, to heat a wire for the cautery, or to give "faradaic" shocks. To this end the transformer has three pairs of terminals, marked respectively light, cautery, and shock. An 8 c.-p. incandescent lamp fixed above the apparatus shows when the current is passing through the primary. The strength of the induced current is regulated by varying the position of the primary with respect to the secondary. For the purpose of the cautery a maximum current of 20 amperes at a pressure of 6 volts can be obtained. If a continuous current is supplied to the primary it is interrupted by a special key.

The Arrol Train Approach Indicator.—The distressing accident at Yorkhill, near Glasgow, on September 11th, which resulted in the instantaneous death of five platelayers, who were run over by an unobserved express train, has stimulated the inventive mind of Sir William Arrol to produce an electrical train approach indicator. This consists of a small apparatus, which is temporarily fixed beside one of the rails at a sufficient distance in advance of the point where the road is under repair. An electric bell connected with this apparatus is placed near the men. The wheel tyres of an approaching train depress a spring, and complete a circuit which sets the bell in motion, and so warns the workmen of their danger. The apparatus, which Sir William has not patented, and which costs only about 50s., has been successfully tested on the North British Railway.

Berlin.—In a recent number of the *Elektrotechnische Zeitschrift* is given the following interesting table with regard to supply of current from the Berlin central stations:—

Dates.	16 c.p. lamp-hours (private installations).	16 c.p. lamp-hours (street lighting).	Amp. hours (industrial purposes).
August to December, 1885 ...	635,800	—	—
1886	5,052,024	50,890	—
1887-88 (1½ years)	11,932,000	104,682	—
1888-89	19,563,000	332,674	129,564
1889-90	41,850,000	361,052	695,910
1890-91	59,240,000	363,438	2,744,576

Asbestos Porcelain.—In a recent communication to the Académie des Sciences, M. F. Garros called attention to a new form of porcelain brought out by him. He takes asbestos fibre and reduces it to a fine powder; if pure it exhibits an exceedingly white appearance, but if traces of iron oxide are present there is a slightly yellow tint. In the latter case the oxide is removed by sulphuric or hydrochloric acid. The powder is then made into a paste, moulded into shape, dried slowly, and baked (1200°C.) from 17 to 18 hours. If placed in a very high-temperature furnace, a remarkably-transparent species of porcelain is obtained. This "asbestos porcelain" has already been used for filtration and sterilisation purposes, experiments showing that it is a more rapid and effective filterer than ordinary porcelain, and that the pores are less liable to become clogged up.

Gutta-Percha.—*The Times* of Wednesday contains the following:—"The steamer 'Cachar,' which arrived from Tonquin on Friday at Marseilles, brought back M. Serullaz, who went out two years ago on a mission from the Minister of Posts and Telegraphs, in search of the Isonandra gutta-percha tree in Malaysia. The disappearance of this tree has threatened with great embarrassment, if not with extinction, the submarine cable manufacture. But M. Serullaz has discovered large forests of these trees, and has hit upon practical ways of collecting the gum without destroying the trees as the natives inevitably do. M. Serullaz has been allowed to transport several hundreds of the trees, from ten to fifteen years old, to Algiers, and their cultivation will be attempted also in Guiana. M. Serullaz has left for Algiers with his cargo, which is artificially warmed on board the 'Cachar.'"

Action of Acids on Aluminium.—One of the most cherished beliefs, says *Industries*, concerning this overrated and underrated metal has been that it is not appreciably attacked by nitric and sulphuric acid; and on the strength of this belief its use has been suggested for purposes as diverse as the replacement of platinum in the Grove battery and of cast iron in a nitric acid still. The hopefulness of these suggestions has now been largely discounted by some experiments of M. Leroy, who has shown that aluminium is appreciably soluble in nitric and sulphuric acid of various strengths and different tempera-

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tures. Nor can this action be ascribed to the presence of hydrochloric acid as an impurity in the commercial acids, as was recently suggested by Mr. Hunt, of the Pittsburg Reduction Company, seeing that the effect of the pure acids does not differ sensibly from that of commercial specimens.

The Roberts-Austen Pyrometer.—At the Cardiff meeting of the British Association, Prof. Roberts-Austen described his new self-recording pyrometer to the Chemical Section. In this instrument, pieces of pure platinum are connected with pieces of platinum containing 10 per cent. of rhodium, and are placed in circuit with a mirror galvanometer. The spot of light falls on a slit, before which a photographic plate passes at a given rate, by which means a curved line is traced, corresponding to the variations in temperature of the heated thermal junction. A similar thermal junction is maintained at a constant temperature by immersion in water. The correctness of the indications are reliable up to the melting point of the platinum employed, within a range of 10 per cent. of possible error, which is accurate enough for most practical purposes. Prof. Roberts-Austen has employed his pyrometer in the investigation of the thermic changes which take place during the cooling of metals and alloys.

The Board of Trade and Overhead Wires.—At the last meeting of the Worcester Watch Committee a communication was received from the Board of Trade, intimating that they had received information of the intention of a private company in Worcester to supply electrical power by overhead wires, and asking the name of the company, in order that the Board might serve a notice requiring conformity to the Board's regulations.—The Town Clerk said the Council had set their face against overhead wires in view of the danger they might be, and had approved a suggestion of putting them underground. It would be unfair if others were to adopt the cheaper method of putting them overhead. It appeared, however, that nothing could be done but to compel the company to put the wires a certain height above the street.—It was suggested that the Town Clerk should inform the Board that the Council knew of no company proposing to supply electricity by overhead wires, and should ask them for a copy of their more recent regulations.

The Electric Launch "Zürich."—The following particulars from *L'Electricien* with regard to the electric launch, "Zürich," which attracted much attention at the recent Frankfort Exhibition, may be of some interest. The launch was constructed by MM. Escher Wyss et Cie., of Zürich, and the Oerlikon Maschinenfabrik. The hull was of steel, and the boat was capable of carrying 100 passengers. The dimensions were :—Length, 53ft.; beam, 10¼; mean draught, 3½ft. The screw, which was 28in. in diameter, was coupled direct to a 10 H.P. two-pole Brown undertype dynamo, and is running at 350 revolutions. Power was supplied by a battery of 56 Schoop 31-plate gelatinous accumulators, having a capacity of 450 ampere hours, and a maximum discharge current of 80 amperes, and weighing in all about 5 tons. The total weight of the electrical equipment was 6½ tons, that of the boat being 15 tons. The motor, when running at 365 revolutions, and absorbing 10 H.P. (102 volts × 75 amperes), propelled the launch at the rate of 8 miles an hour; when only 8 H.P. was absorbed the speed was still 7 miles an hour.

A New Edison Central Station.—The new station of the Edison Electric Illuminating Company, of New York, now in course of construction on Elm-street, will, says the *Electrical World*, embody many new features in central lighting station practice. The entire scheme has been worked out by Mr. J. Van Vleck. His recent trip to Europe, and thorough study of practice over there, resulted in his recommending to his company the adoption of large generators of from 1,000 to 5,000 H.P. It is the intention to use very high steam pressure and new quadruple expansion engines. These, together with the "hot blast" system, an elaborate system of economisers and many other refinements, will give an economy never before attained in engineering practice. Many other things are promised, among which will be the Van Vleck system of "cannon piping." This consists of copper pipe wound with steel wire, and fittings made of gun metal. Mr. Van Vleck is confident that by the arrangements contemplated he will be able to obtain one-horse power from each pound of coal. Among the electrical features will be large Sir William Thomson voltmeters, with dials three feet in diameter, so that the pressure of the system can be read all over the station. The main ampere meters are to be direct-reading instruments on the balance principle. When completed the station will be 160ft. high, and occupy a plot of ground 200 by 100.

Coastal Telegraph Communication.—An important fact has been made known in connection with the recent alarm concerning the safety of H.M.S. "Banterer," says the Plymouth correspondent of *The Times*. Owing to her non-arrival after leaving Queenstown, and in view of the stormy weather, anxiety was manifested as to her safety on Wednesday and Thursday of last week. On Friday afternoon a vessel was prepared for sea to go in search of the "Banterer," when news came that she had been seen passing Clovelly. It has been ascertained, however, that both on Wednesday and Thursday she was observed from Hartland Point Lighthouse, lying at the back of Lundy Island, in the Bristol Channel. The lighthouse keepers, however, did not communicate this fact to the naval authorities, *because the nearest telegraph station to Hartland is four miles distant;* and they were unaware of the concern which was felt for the "Banterer's" safety. Thus a strong illustration is supplied of the necessity for connecting the coastguard stations and lighthouses by wire with the general telegraphic system of the country. If the Hartland Lighthouse keepers had been able to telegraph the whereabouts of the "Banterer," all the fears that were entertained concerning her and the expense of fitting out a vessel to go in search of her would not have occurred. Lundy Island was formerly connected by telegraph cable with the mainland, but the cable was broken nearly two years ago, and the Post Office have never yet been induced to repair it. *The omission to connect Hartland with the telegraph office by wire is the more inexplicable because a telegraph wire runs within five hundred yards of the lighthouse.*

Brighton.—*The Sussex Daily News* has the following very pertinent remarks with regard to the position of electric lighting matters at Brighton :—"The situation is briefly this. The Corporation have for several years been in the enjoyment of authority to supply electricity within the borough, but until September last had not chosen to avail themselves of that authority. They had, nevertheless, used their privileges unmercifully to prevent the Company from attaining such a position as would enable them efficiently to supply the needs of the town. . . . At length the Board of Trade interfered, and refused to allow such an unfair state of things to continue. . . . Driven to bay, the Corporation undertook to exercise their long-neglected powers, and after the utmost possible delay electricity works and mains have been established, and a certain extent of supply has been accomplished. . . . The Corporation mains at present only extend to a very few streets indeed. Undoubtedly they are the most important ones, for they have been carefully selected as likely to prove the most remunerative, and the district which they surround includes very valuable property. But it must be remembered that these half-dozen principal streets do not comprise a tenth or even a twentieth part of the houses within the small district through which they run, and that the area of that district is roughly about a tenth of the whole borough. . . The original estimate of £32,500 has already proved wholly insufficient, and a further expenditure of £8,500 has been determined upon. For this large outlay the general body of ratepayers get no advantage whatever. Not a single public lamp is lighted by electricity, and only about one in a hundred of the ratepayers has the opportunity of obtaining electricity for private purposes. . . . The Company may by no means improbably obtain the authority of the Board of Trade to do what the Corporation will not, or cannot, do. . . . The Council will probably find in time, as has often happened before, that they must make a worse bargain than they have already refused. Meantime, there is every reason to believe that the Company will be very generally supported in the town by those who regard the policy of the Council as wanting in justice."

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THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 141.*)

§ 43. **Methods of Finding M.**—Either of the two methods of finding N given in § 36 gives a means of calculating M, since the value of N for either circuit, determined on the supposition that the magnetic force is entirely due to unit current flowing in the second circuit, is identical with M. We shall see examples of both methods a little later.

There is a third method of finding M, depending on the theory that when a current flows in any circuit, a state of motion is set up in the ether around it, and that kinetic energy is stored up in that motion. We saw in § 15 that there was reason to believe that wherever a magnetic force H is acting there is a storage of energy in the medium of amount $H^2/8\pi$ ergs per cubic centimetre. Now, if we have a pair of circuits A, B, carrying currents i, i', each will produce a distribution of magnetic force, and the resultant magnetic force at any point will be the resultant of the magnetic forces due to the two currents separately. If H_1, H_2 are the magnetic forces due to the two currents at any the same point, then since each is a vector and can be represented in direction and magnitude by a straight line, it follows at once, from a well-known result in Trigonometry, that the resultant magnetic force H is given by the equation $H^2 = H_1^2 + H_2^2 + 2 H_1 H_2 \cos\theta$, where θ is the angle between H_1 and H^2. Hence, the part of the store of energy in the field which is due to the coexistence of the two currents is $H_1 H_2 \cos\theta . 1/4\pi$ ergs per cubic centimetre. Integrating this through all space we find that the total amount of what we may term "mutual" energy is $\iiint \frac{H_1 H_2 \cos\theta}{4\pi} dv$ ergs, where dv is an element of volume.

Now, suppose that the current i' is gradually started in B, the current i being maintained constant in A. By Faraday's law of induction an electromotive force is produced in A equal to $M\, di'/dt$ in the opposite direction to the current i. Since this current is kept constant, the batteries or other electromotive agencies in A must be doing work at the rate $i M\, di'/dt$ ergs per second in driving the current against this E.M.F. Hence, the whole amount of work expended by the batteries in A, over and above that spent in heating the wires is $i M \int dt . di'/dt = M i i'$ ergs. Again, since the current in A has been kept steady, the work expended by the batteries in B in establishing the current i', is the same as if there had been no current in A. Where has the $M i i'$ ergs of energy given out by the batteries in A gone to? Sir William Thomson long ago pointed out that it must be stored up somewhere as kinetic energy. We now believe that it is stored in the ether. Equating the energy which the battery in A has sent out into the ether in consequence of starting the current in B, to the part of the store of energy which depends upon the coexistence of the two currents, we obtain

$$M i i' = \frac{1}{4\pi} \iiint H_1 H_2 \cos\theta \, dv.$$

Taking H_1 H_2 as the magnetic forces due to unit current in A and B respectively, we have

$$M = \frac{1}{4\pi} \iiint H_1 H_2 \cos\theta \, dv.$$

Although extremely instructive, this method of determining M is not so practically useful as the first and second methods. It can be very easily applied to the case in which the two coils are long solenoids, one being wound over the other.

These three methods will be found in Maxwell's Paper on "A Dynamical Theory of the Electro-magnetic Field," Royal Society *Transactions*, Vol. CLV., or in Vol. I. of his collected "Scientific Papers."

§ 44. **Mechanical Forces between Currents.**—We have seen (§ 35) that the mutual potential energy of a pair of currents of strength i, i' is $-M i i'$, where M is a quantity which depends upon the geometrical configuration of the two circuits. M can be calculated by Neumann's formula $M = \iint \cos\epsilon \, ds \, ds'/r$. (§ 41), or in other ways. We proved, in § 30, that if the number of lines of induction due to some foreign magnetic system which pass through any circuit is N, then when this circuit carries a current i, it experiences a mechanical force X dynes where $X = i\, dN/dx$, X being measured in the direction in which x increases. But if the magnetic system is a current of strength i', we have $N = M i'$, so that $X = i i'\, dM/dx$ dynes. Thus the first step towards the calculation of the mechanical forces exerted by one circuit on the other is to find the appropriate differential coefficients of M.

Since in this method we deal only with closed circuits, we shall obtain a value for the mechanical force, free from any indeterminateness or uncertainty. It is indeed possible to assign laws of the action of an element of one current upon an element of another current, but we cannot prove them experimentally since we can only deal with closed circuits, and the various laws all give the same result when applied to closed circuits. We shall explain briefly two of these laws, taking the law of Ampère, because it was the first which was developed, and the law of M. Reynard, because it follows very easily from the results we have already obtained.

§ 45. **Ampère's Law.**—Ampère was the first to make an attempt to determine the action of one element upon another. He made many experiments upon the mutual action of a pair of currents, devising several ingenious pieces of apparatus for this purpose. Living as he did in the days of "Action at a Distance," he was unable to imagine that the action between a pair of elements could be other than an attraction or repulsion along the straight line joining them, or that the forces experienced by the two elements could be unequal. He, therefore, determined what law of action between a pair of elements would make the forces experienced by the two elements equal and opposite and directed along the straight line joining them, and at the same time give results agreeing with his experiments when applied to closed circuits. The result of his work was to show that one element *attracted* any other with a force $i i' (2\cos\epsilon - 3\cos\theta\cos\theta')\, ds\, ds'/r^2$, where ϵ is the angle between the directions of ds and ds', and θ, θ' are the angles made by r with ds and ds' respectively. According to this formula, two elements, parallel to each other, and both perpendicular to the radius r, attract each other with a force $2\, i i'\, ds\, ds'/r^2$, since $\theta = \theta = \pi/2$ and $\epsilon = 0$. Again, for two elements in the same straight line $\theta = \theta' = \epsilon = 0$, and therefore the attraction is $i i' (2-3)\, ds\, ds'/r^2 = -i i'\, ds\, ds'/r^2$, the negative sign indicating repulsion. The experiment which was thought to be confirmatory of this result has been shown by Maxwell to be capable of a quite different explanation. See Maxwell, Vol. II., § 687.

Ampère's result can be obtained from Neumann's formula in the following way. If E be the potential energy of a pair of closed currents, then $E = -i i' \iint \cos\epsilon \, ds\, ds'/r$. Keeping one of the circuits fixed, alter the position of the other in any way and calculate the increase in the potential energy. An application of the Calculus of Variations shows that if δE is the increase in E, and δr the increase in the radius r, joining any pair of elements, then

$$\delta E = i i' \iint \frac{(2\cos\epsilon - 3\cos\theta\cos\theta')}{r^2} ds\, ds'\, \delta r.$$

But if each element had attracted any other with a force $i i'\, ds\, ds'\, (2\cos\epsilon - 3\cos\theta\cos\theta')/r^2$, the work spent upon the elements in separating them still further by the distance δr, and therefore the increase in their potential energy would have been $i i'\, ds\, ds'\, \delta r\, (2\cos\epsilon - 3\cos\theta\cos\theta')/r^2$. When we take account of all the elements in both circuits, we obtain the same result as that deduced from Neumann's formula. Thus, if it is any pleasure to us, we may suppose that each element attracts every other one, according to Ampère's law. No one will ever be able to prove that our supposition is wrong; but, on the other hand, we shall never be able to prove that it is right. The method of deducing Ampère's law from Neumann's

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formula will be found in Prof. Chrystal's article, "Electricity," in the "Encyclopædia Britannica," p. 70.

§ 46. **Reynard's Law.**—We have seen in § 32 that any element ds carrying a current i may be regarded as producing at any point a magnetic force $i\,ds \sin\theta \,.\, 1/r^2$, where r is the distance of the point from ds and θ the angle between r and ds. Since we are dealing with air, this is also the value of the magnetic induction. The direction of the magnetic induction is at right angles to the plane of r and ds. Again, in § 31 we proved that any element ds' carrying a current i' when subjected to the action of magnetic induction B experiences a force $\mathsf{B}\,i'\,ds' \sin\phi$ at right angles to the plane of B and ds', ϕ being the angle between the positive directions of B and ds'. If we suppose that B is due to the element ds, then B is at right angles to the plane of r and ds—*i.e.*, is along the normal to that plane. Suppose now that the second element $i'\,ds'$ makes an angle ϕ with this normal, then, if we combine the two laws mentioned above, we find that we may regard the element $i\,ds$ as exerting upon the element $i'\,ds'$ a force $i\,ds \sin\theta \,.\, 1/r^2 \times i'\,ds' \sin\phi = ii'\,ds\,ds' \sin\theta \sin\phi \,.\, 1/r^2$ at right angles to the plane containing the normal and the element $i'\,ds'$. This direction lies in the plane of r and ds at right angles to the projection of ds' upon this plane.

The direction of this force for varying inclinations of r to the projection of ds' is, perhaps, most easily understood from Fig. 41. All the lines here are supposed to be in the plane of

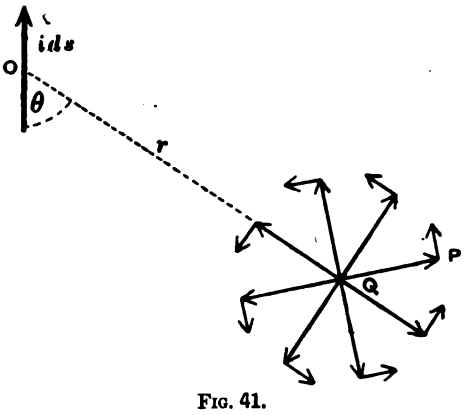

FIG. 41.

the paper which is the plane of r and ds. Q is the centre of the element ds', and Q P is the projection of its direction upon the plane of r and ds. The small arrow at the end of Q P indicates the direction of the force experienced by ds'. Only in the case in which Q P is at right angles to O Q does the direction of the force pass through ds. The inclination of ds' to the plane of r and ds only affects the *amount* of the force; the *direction* of the force depends upon the inclination of r to the projection of ds' upon that plane. It is easily seen that the force exerted by ds' upon ds is in general neither equal to that exerted by ds upon ds' nor in the same direction.

We will now find the force experienced by ds' according to Reynard's law in the two cases which we have already investigated by Ampère's law. In the first case we have $\theta = \phi = \pi/2$, so that the force is $ii'\,ds\,ds' \,.\, 1/r^2$, and is an attraction along r. This result is one-half of that given by Ampère's law. In the second case, $\theta = 0$, $\phi = \pi/2$, and the force vanishes, while Ampère's law gave a repulsion. Thus these two laws give entirely discordant results when applied to elements, although they agree when applied to two closed circuits. An account of Reynard's formula will be found in "Mascart and Joubert," English edition, Vol. I., § 476. Both in "Maxwell" and in "Mascart and Joubert" will be found accounts of some other theories which have been proposed for the law of inter-action of two elements.

We shall now leave the subject of "elements," and pass on to the determination of the value of the coefficient of mutual induction for a pair of circuits. Practically the only shape of circuit which is employed is circular, so that we shall confine ourselves to circuits of this form,

(To be continued.)

A THERMO-ELECTRIC STANDARD OF ELECTRO-MOTIVE FORCE.*

BY HENRI BAGARD.

It has already been proposed to employ thermo-electric couples as standards of electromotive force; but those made use of hitherto being composed of two metals, the electromotive forces obtained have been extremely small and varied with each sample of metal. I sought to determine whether a thermo-electric couple composed of two liquids, that is to say, of two bodies having an invariable structure, possessed, for any two temperatures of their contact surfaces, a well-defined electromotive force. By taking, as my liquids, an amalgam of zinc, containing ·0005 of zinc to 1 of mercury, and a saturated solution of sulphate of zinc (0deg.), I obtained a considerable electromotive force, the couple being non-polarisable.

I dissolve the zinc in the mercury under a layer of sulphate of zinc, which prevents oxidation, and which I remove rapidly at the moment of using the amalgam by means of a piece of blotting paper. The apparatus is constructed in the following manner:—Three tubes, A B C, closed at the bottom, contain the amalgam and sulphate of zinc super-imposed. Tube A is brought to the boiling point of water at atmospheric pressure, a temperature which I will denote by T. Tubes B and C are kept in melting ice. The sulphate of A communicates with that of B by a syphon filled with that liquid. In the same way the amalgams of A and C are connected by a syphon filled with amalgam. Two insulated platinum electrodes plunge into the amalgams B and C, between which there exists consequently only the thermo-electric difference of potential. The sulphate which covers the amalgam C is merely intended to protect it against the effects of contact with the air. The sulphate A is covered by a layer of paraffin to prevent evaporation. In this couple the hot amalgam is the positive pole to the external circuit.

Several couples, separately prepared and compared with one another on different dates, always gave the same electromotive force—about ·0001 volt—and remained non-polarisable. This couple may, therefore, be used as a standard.

I investigated the action of the couple when one of the surfaces in contact was kept at 0deg., and the other at a temperature t, varying between 0deg. and T. Here are some of the numbers obtained, T being 99·3deg.:—

t	15·7°	33·6°	40·7°	48·6°	54·3°
$f(t) = E_0^t/E_0^T$.	·148	·320	·392	·470	·528

Taking T = 99·3deg., the function $f(t)$ is exactly represented by the two-term formula

$$(1.)\quad f(t) = ·0093\,t + ·00000774\,t^2.$$

Thus the representative curve is, as in most instances of bi-metallic couples, a parabola, and the curve turns its convexity towards the line of temperatures.

I next measured in absolute measure by means of a capillary electrometer sensitive to $\frac{1}{10000}$ of a volt, the E.M.F. force E_0^T of the standard couple, by compensation with the difference of potential produced at the ends of a resistance equal to the legal ohm, by a suitable current the value of which I determined by the electrolysis of nitrate of silver, I arrived at a mean of several determinations and making use of the formula (1)

$$E_0^{100} = ·1167 \text{ volt},$$

the error to be feared being of the order of ·0001 volt. The value of E_0^{100} is, therefore, about one hundred times greater for the couple under investigation than for an iron copper couple which gives about ·0011 volt. Bringing the value of E_0^{100} into the first equation, we obtain the following expression for the E.M.F. for temperatures between 0deg. and 100deg.

$$(2.)\quad E_0^t = ·001077\,t + ·0000009\,t^2.$$

To determine the influence of the richness of the amalgam in zinc, I compared couples containing different amalgams with

* *Comptes Rendus*, Vol. CXIII., No. 24.

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the standard couple by the method of opposition already employed. When the proportion of zinc is less than ·00005 the couple polarises. With larger proportions the couple becomes non-polarisable, and the E.M.F. decreases continuously as the amount of zinc increases, as is shown by the following table:—

Weight of zinc to 1 of mercury...	·00025	·00035	·00045	·0005	·00055	·00075
E_0^{100}	·1197	·1183	·1171	·1167	·1164	·115

To sum up. The couple I have investigated is absolutely constant between two given temperatures; it can be used on closed circuit without polarising, and its E.M.F. for temperatures between 0^0 and t^0 is given by formula (2). Finally, it is not necessary to weigh the zinc to be dissolved in a given weight of mercury with great precision, since the above table shows that the variation of E_0^{100} does not amount to ·0001 when the proportion of zinc varies by ·00001, or $\frac{1}{10}$th. This research was carried out in the Physical Laboratory at Nancy.

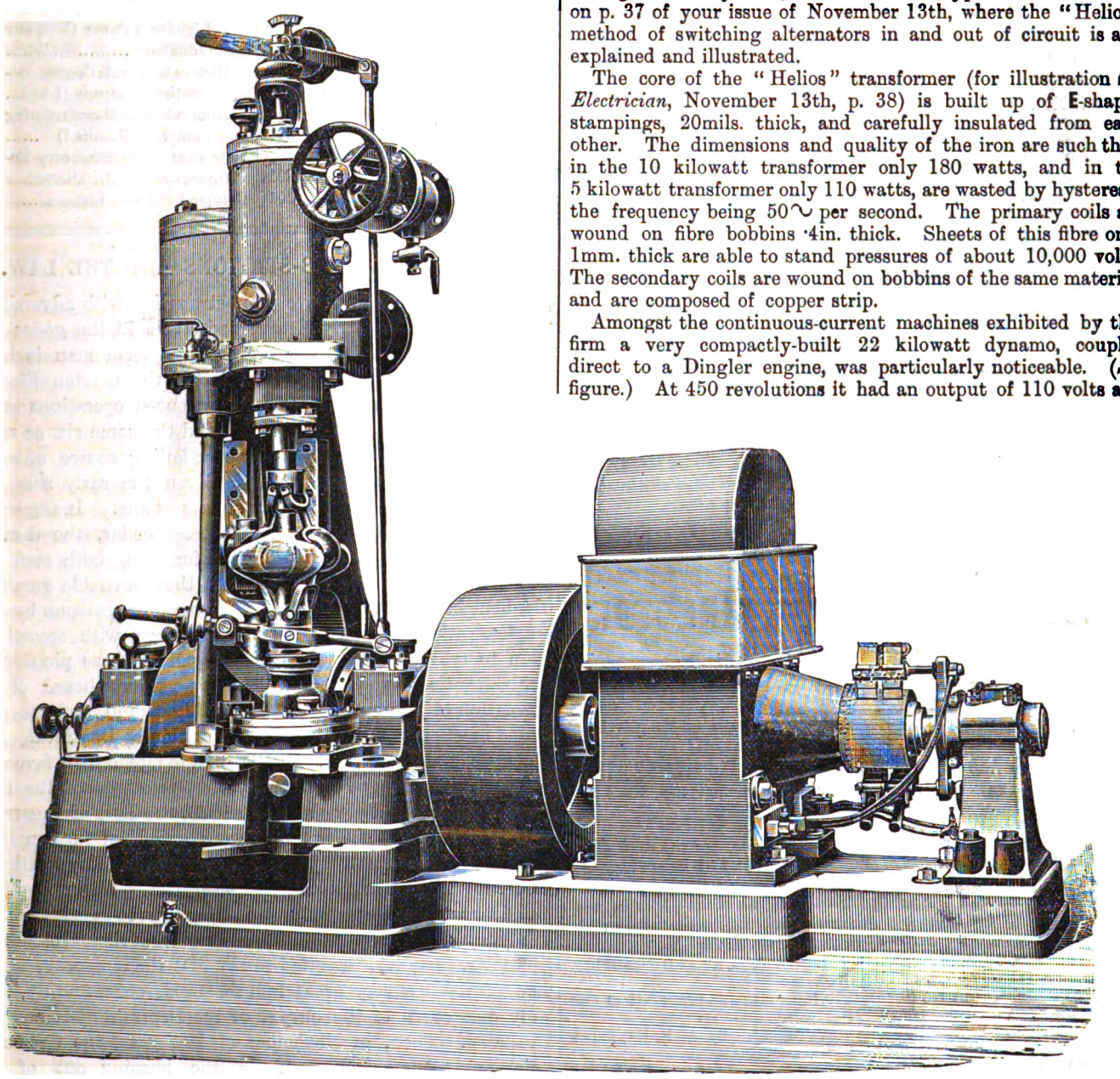
THE FRANKFORT EXHIBITION.—XVIII.

(FROM OUR SPECIAL CORRESPONDENT.)

Reference has several times been made in these articles to the fine show made by the "Helios" Company, of Cologne. Their chief exhibit was a 600 H.P. alternator, driven direct by a horizontal steam engine by Paucksch, of Landsberg. The steam engine was compound with jet condensation, and provided with expansion gear of the Armington and Sims type. An engine of this description takes up a good deal of room, but this is perhaps compensated for by the ease with which the moving parts can be got at and examined while it is at work. As regards the dynamo, it is of the same type as that described on p. 37 of your issue of November 13th, where the "Helios" method of switching alternators in and out of circuit is also explained and illustrated.

The core of the "Helios" transformer (for illustration see *Electrician*, November 13th, p. 38) is built up of E-shaped stampings, 20mils. thick, and carefully insulated from each other. The dimensions and quality of the iron are such that, in the 10 kilowatt transformer only 180 watts, and in the 5 kilowatt transformer only 110 watts, are wasted by hysteresis the frequency being 50∿ per second. The primary coils are wound on fibre bobbins ·4in. thick. Sheets of this fibre only 1mm. thick are able to stand pressures of about 10,000 volts. The secondary coils are wound on bobbins of the same material, and are composed of copper strip.

Amongst the continuous-current machines exhibited by this firm a very compactly-built 22 kilowatt dynamo, coupled direct to a Dingler engine, was particularly noticeable. (*See* figure.) At 450 revolutions it had an output of 110 volts and 200 amperes, and was chiefly used for accumulator charging and for providing exciting current for the large alternator. The field-magnets were built up of thin iron strips. All the "Helios" dynamos are built with self-oiling bearings by means of rings, the firm being the first in Germany to apply this system to dynamos.



22-kilowatt Helios Continuous-Current Dynamo, coupled direct to Dingler Engine.

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TRANSFORMER SUB-STATIONS AND THE LAW.

The spectacle of a brave man struggling with adversity is said to be a particularly pleasing spectacle to the gods; and if, for the purposes of the proverb, the term man includes limited liability company, the career of the London Electric Supply Corporation since it first commenced operations under its old title of Sir COUTTS LINDSAY and Co. some six or seven years ago, must have been a never-failing source of satisfaction to these sublime gentry. Even the early successes of this bold enterprise proved its bane. Inaugurated in a modest manner in a Bond-street cellar, the demand for current grew so rapidly that before long both staff and plant were being over-worked, with the inevitable result of frequent breakdowns. Threats of injunctions also soon became unpleasantly numerous. It was, therefore, with something akin to relief that all who wished well to these pioneers of central-station lighting and alternate currents heard of the formation of a big company with a big capital, and the proposed erection of a huge generating station at Deptford. But the gods, apparently, were not disposed to forego their favourite amusement. At one of the very first meetings of the then new Company on December 21st, 1888, the Earl of CRAWFORD had to report that the building work had been thrown back "owing to the excessively bad summer and the rainy weather," and that some two months had been lost. When Deptford finally was ready to supply current the mains to take it were not ready, and at the meeting of the shareholders at the end of March, 1890, Mr. FERRANTI regretted to say that the temporary mains had proved "a very great failure," and, consequently, that only one-fourth of the output of the Deptford dynamos was available. Then, in November of last year, the demon of mischief surpassed himself by the burning out of the temporary transformer sub-station at the Grosvenor Gallery, which resulted in a three-months' suspension of the supply. And now Mr. Justice KEKEWICH has been moved to grant an njunction restraining the Lond on Electric Supply Corporation from using the buildings and cellars belonging to them in New Bond-street as a converting and distributing station, or otherwise, so as to occasion a nuisance to Messrs. SAVORY and MOORE.

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The daily papers, so far as we have seen them, cite this action of "Savory and Moore *v.* the London Electric Supply Corporation" as an illustration of the great danger arising from the erection of electric light supply works in the heart of a city, in contiguity with other buildings. This alarmist view of the case may, perhaps, be excused since the plaintiffs talked of electric cables and step-down transformers of such a highly inflammable and combustible nature that even with the greatest precautions, both in the construction of the buildings containing them and in the mode of carrying on the business of distribution, there was a great risk of fire. It is, however, somewhat difficult for the lay mind to see the full force of the reasons upon which Mr. Justice KEKEWICH based his decision. It was, he said, clear beyond dispute that there was now no imminent danger against which the plaintiffs were entitled to protection; but since it did not appear what use was going to be made of the rest of the building other than the cellar, or that danger of fire had been completely obviated, he granted the injunction asked for. "The powers and therefore the dangers of electricity," the learned Judge is of opinion, "cannot be regarded as known even by scientific men with sufficient accuracy to justify a positive statement respecting possible results under hypothetical circumstances, especially when the locality is in the heart of a crowded city."

Our utter ignorance of the nature of electricity cannot, of course, be disputed for one moment. But this and much more may be conceded without in any way admitting that a properly constructed, properly managed alternate-current transformer sub-station constitutes a danger to the community half so grave as those huge cumuli of wood which are dotted about all over London, or those stores of "spirit tinctures and other spirituous preparations," such as are kept by Messrs, SAVORY and MOORE themselves, and which the defendants, with grim humour, insisted were a source of considerable danger to their distributing centre. An electric light supply station with its whirling armatures, high-speed engines, and high-pressure boilers, might, perhaps—its comparative harmlessness notwithstanding—be considered by the judicial mind as too risky to form a feature of a populous district. But a transformer sub-station, even if "extra high-pressure" currents all the way from Deptford are led into it, can with a moderate expenditure of money and constructive skill be made absolutely innocuous. A fireproof compartment not so very much larger than a respectable strong room would hold transformers and manipulatory apparatus sufficient to supply an entire district. Cables need not be "highly inflammable" nor switches "highly combustible;" and in this way, while the chances of fire can be reduced to a minimum, its area can at the same time be strictly limited. The disastrous fire of November 20, 1890, which gave rise to the present action, occurred in a temporary receptacle at a moment when everything was favourable to a big blaze. Precautions have since been adopted which were satisfactory to the Court; but "the defendants' plans above the basement wanting in precision, and a disposition to be guided by circumstances, and the exigencies of trade" being "an awkward factor in the sum of possible results," the Grosvenor Gallery transformer sub-station will have to go, unless the Corporation climbs down and is allowed to give an undertaking, on appeal, that the upper part of the building will not be used for "dangerous" purposes. Although this decision may not be a very serious matter for the London Electric Supply Corporation with its Trafalgar-square and Victoria sub-stations to fall back upon, it may prove an unwelcome addition to the many dis-services rendered by fate to the cause of electrical distribution by means of alternate currents.

REVIEWS.

Les Électro-thermo-cautères. Par le Dr. CHEVAL. Extrait du *Journal de Médecine, de Chirurgie et de Pharmacologie de Bruxelles.* (Brussels: October, 1891.)

In this pamphlet, which we have received from the editor of the *Journal of Medicine and Surgery* of Brussels, the author discusses the problems of heating surgical cautery wires. Although the galvano-cautery has been long employed in surgery, it is only in recent years that its use has become common. At present we believe that few of those who are engaged in active surgical practice are without an apparatus of some kind for galvano-cautery. This is due partly to modern improvements in primary batteries, and partly to the general introduction of accumulators.

Dr. Cheval has a strong preference for this latter source of current, and for use in the consulting-room no doubt an accumulator is very convenient; but when the cautery operation has to be performed at the house of a patient the weight and bulk of accumulators become a serious objection to their use. And it is in such cases where the cautery has to be taken to the patient that the real difficulties of the matter begin, especially if large cauteries, demanding 40, 50, or 60 amperes, have to be heated. We are not so sure that primary batteries have as yet been superseded for all surgical cautery purposes. In most cases comparatively thin platinum wires are employed, needing only 10 or 15 amperes to heat them; and this can be done quite well with some of the modern types of portable sealed batteries, coupled up in parallel, at less cost in weight and bulk than that of an accumulator, and with the additional advantage that all risk of accident through upsetting of corrosive liquids is avoided. It is not impossible for an open battery to come to grief at the last minute; and we shudder to think of the consequences if, after the hour of operation has been fixed, assistants engaged, and nurses provided, there should occur some unfortunate jerk or accident to the battery, spilling the corrosive liquids and throwing the battery out of gear, and perhaps ruining the clothes and the temper of the operator. The bichromate batteries, which are so much in favour with medical men, are at all times rather awkward to carry about, and are very unsatisfactory in several ways. Many of our readers are, no doubt, familiar with the instrument makers' cautery batteries of bichromate type, with rows of plates of zinc and carbon in each cell, the whole enclosed in a polished mahogany box, which effectually conceals the condition of the battery connections inside; but it is not everyone who can realise the perpetual worry and annoyance of such a thing, nor the cost of having it kept in order. At the present time, however, those who have rebelled against the tyranny of the bichromate battery can make use of the improved type of chloride of silver cell, which is sealed up, small and fairly convenient; or they may find what they require in one of the more modern dry batteries. Either of these forms of battery are suitable for cautery wires requiring up to 15 or 20 amperes of current to heat them. At the same time we think that the best possible form has not yet been attained for surgical cautery purposes, and that something might yet be devised of the dry battery type, with large flat plates, something after the plan of Volta's original pile, but with means for connecting them in parallel. Such an arrangement should be possible with an internal resistance low enough for it to yield as much current as would be wanted for cautery purposes, at least for the short periods of time during which a cautery requires to be heated. The liability to polarisation could hardly be a serious objection, seeing that the wire is rarely used for more than thirty seconds at each operation. There are not many cauteries which absorb so much as 40 or 50 amperes, though we have heard of one or two giants needing 60 amperes, which give considerable anxiety to those who are responsible for raising them to the required heat.

There is one point which Dr. Cheval has not alluded to in his paper, but which we think is of great importance, and that is the damage likely to be done to an accumulator if it be discharged at an excessive rate through a big cautery of low resistance. This is a point which is not thoroughly appreciated by medical men, if we may judge from a row of accumulators

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which we lately saw in the shop of an instrument maker; to all appearance they seemed new and good, but every one of them had been totally spoiled by the trying nature of the work to which they had been put.

The writer of the pamphlet very properly insists upon the importance of having proper leads, and handles of suitable dimensions for cauteries. In fact, instrument makers and medical men might very well pay a little more attention to these points, and to the matter of securing better contacts in their instruments. We have seen the gutta percha insulation melted off a thin copper wire which was being used to carry the current to a large cautery.

Dr. Cheval next leads up to what is perhaps the most important part of his paper, namely, that iron wire is better than platinum for cautery purposes. He quotes the experiments of Preece on the number of amperes necessary for heating to redness wires of different metals. Preece found that for wires one millimetre in diameter platinum required 40 amperes, and iron 24 amperes. This gives a considerable advantage to iron; and an additional advantage is claimed for it by Dr. Cheval, because with iron wires the rise of resistance with increased temperature is greater than with platinum. It seems to us, however, that here our writer is trying to prove too much; we think Mr. Preece's figures have already included the advantages gained in this way for the iron wire. The great difference between 24 amperes and 40 amperes would not be expected from the specific resistances of the two metals at ordinary temperatures; for these are 9·82 and 9·15 respectively, and the superiority of iron over platinum for cautery purposes must be due to the difference of their specific resistances at a red heat. The specific heats of the two metals (·112 for iron and ·032 for platinum) differ considerably, but the results are but little influenced thereby.

Dr. Cheval says that he found, after replacing his platinum wires by iron, that cauteries which had required from 15 to 25 amperes when made with platinum were perfectly heated with a current of from 7 to 12 amperes when iron was used. Nor was that the only advantage gained; for he found that his cautery handles, which could hardly convey the large currents needed for the platinum wire without serious loss from heating, were able to do so perfectly for the iron.

He also satisfied himself that no bad effects need be feared from the use of iron wire through oxidation, or through portions of iron rust being left entangled in the tissues of the wound; and he declares that he has never had any sort of accident with iron wire, nor has he seen any, though he has witnessed the operations "thousands and thousands of times." This, perhaps, is hyperbole, but, at any rate, his experiences seem to be satisfactory.

Moreover, by the ingenious plan of using silvered iron wires, he claims to have been able to prevent oxidation from taking place, and so to protect the wire without affecting its efficiency.

If these results should be confirmed by independent trials in this country the introduction of his methods ought to receive attention at the hands of surgeons and instrument makers here. By the use of silvered iron wire instead of platinum surgeons would gain in all the following points:—(1) Increased ease in heating their cauteries, with a corresponding saving in the bulk of their battery plant; (2) a firmer and stiffer cautery instrument; (3) the instrument would be cheaper.

The remainder of Dr. Cheval's pamphlet is taken up with a description of his installation of 25 accumulators, and of his methods of regulating the current by rheostats and so forth. There is nothing of any particular interest or novelty in this portion of the essay. He also describes a plan for utilising the electric lighting current of the town mains for medical applications, from which we infer that his district is served by a continuous current; but we believe that few medical men would care to run the risks of using a 100-volt current for treating their patients, unless the connections were permanently arranged with a considerable resistance always in circuit; and we feel sure that no patients would willingly put themselves into such a circuit if they knew that so slight a mistake as a plug-key put into the wrong plug-hole, or some other slight error with the resistance coils, might give them such a dose of the remedy as they would be likely to remember for some time.

THE PRINCIPLES OF ALTERNATE CURRENT MEASUREMENT.

BY HUGH ERAT HARRISON, B.SC.

(*Continued from page 171.*)

The Board of Trade, however, authorises the use of "instruments constructed on the principle of the balance, in which, by proper disposition of conductors, forces of attraction and repulsion are produced, which depend upon the amount of current passing, and are balanced by known weights . . . for the measurement of current whether unvarying or alternating."*

In Fig. 6 is shown a diagram of an electric balance. AA', BB' are two pairs of fixed coils; between them is suspended about a horizontal axis PQ, like the beam of a balance, a third pair of coils MM'. If a current passes through the instrument, as indicated by the arrows, bobbin M is pulled and pushed downwards, while M' is pushed and pulled upwards; the beam is then brought back into the position of equilibrium, which it has when no current passes, by putting weights into a pan S; but to obtain more perfect adjustment, riders, similar to those used on a chemical balance, are also employed, though not indicated in the diagram.

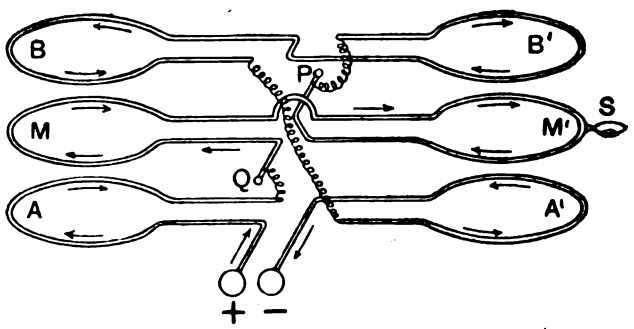

FIG. 6.

In this instrument the forces of attraction and repulsion, with which the conductors carrying the current act on one another, are balanced by the force of gravity acting on the weights, and are thus measured. If the position of two conductors relatively to each other is fixed, the force which they exert on each other is equal to the product of the currents flowing in them multiplied by some constant. But in the case of the balance sketched the same current passes through all the conductors, and as a reading is only taken when the beam has been forced back into its original position, the force necessary to do so is proportional to the *square of the current* flowing.

To determine this constant it is only necessary to put the instrument in series with a silver voltameter and send an unvarying current through the two. If C is the current, as shown by the voltameter, w the weight necessary to bring the beam to its zero position, and k the unknown constant: $-w = kC^2$, hence $k = w/C^2$, k being now determined the value of any current can be calculated by the formula $C = \sqrt{w/k}$.

It is of the utmost importance to note that, while an unvarying current may be measured by means of the balance or the voltameter, neither of these instruments measures currents directly.

The voltameter records the fact that during the time t, a quantity of electricity Q, has passed through it, and the current is calculated from these data by the formula $C = Q/t$. The weights used to adjust the balance indicate not the current, but the *square of the current*, and the current is calculated by means of the obvious formula $C = \sqrt{C^2}$.

These instruments measure, therefore, two totally distinct functions of the current; but if they are both used to determine the same unvarying current, the two values of the current, as calculated by the above formulæ from the data, respectively observed in the two cases, are identical. It is, however, necessary to investigate this question when currents other than unvarying are measured.

* For the description of Sir William Thomson's balances, see *The Electrician*, vol. XXI., p. 368.

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An undulatory current which flows in one direction, like that drawn in Fig. 4, can obviously be measured by a voltameter or a balance, and such a current will now be considered. It will probably, however, be simpler for the non-mathematical if, instead of choosing a current which is always changing, a current which changes suddenly and remains constant for an appreciable interval of time, like that described in Fig. 7, be taken.

Tenths of seconds are marked off on the line O T. These are not drawn strictly to scale in the figure, as it would make it inconveniently narrow. The current is 5 amperes to begin with, and remains constant for 0·1 second; for the second 0·1 of a second it is 11, for the third and fourth 19, for the fifth 11, and the sixth 5, when a fresh cycle commences.

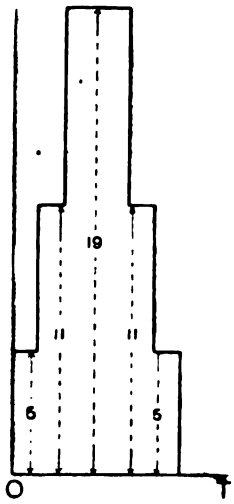

Fig. 7.

If the voltameter is left in the circuit 0·6 of a second, the total quantity of electricity that has passed through it is shown by the area included to be $0·5+1·1+1·9+1·9+1·1+0·5=7·0$, since the current in each case remains constant for one-tenth of a second. The voltameter is in circuit for six-tenths of a second, hence the average quantity which passes per second is $7·0/0·6=11·7$ nearly. Or to put the matter in words, the significance of which will be pointed out shortly,

(*a*) *The time average of the strength of the current at each instant in amperes is*:—

$$\frac{(5\times0·1)+(11\times0·1)+(19\times0·2)+(11\times0·1)+(5\times0·1)}{0·6}$$

$=11·7$ nearly.

Now suppose the same current to be sent through a balance; during successive tenths of a second the beam will be acted upon by forces proportional, not to the strength of the current at each instant, but to the square of the strength at each instant. If f is the force which one ampere could exert, the beam now experiences the forces $f\times5^2$, $f\times11^2$, and $f\times19^2$ succeeding each other at intervals of one-tenth of a second. The average force or time average of the force by which the beam is acted upon is—$0·1f(5^2+11^2+19^2\times2+11^2+5^2)\div0·6=169f$.

The beam is too heavy to pulsate appreciably with the rapidly varying force produced by the current, and can therefore be kept in position by a weight.

A current of one ampere produces the force f; if, then, C is the unvarying current which would produce the force $169f$; $C^2f=169f$, therefore $C=\sqrt{169}=13$; or, expressing matters in the language used in the case of the voltameter measurement,

(*b*) *The square root of the time average of the square of the strength of the current at each instant in amperes is*:—

$$\sqrt{\frac{(5^2\times0·1)+(11^2\times0·1)+(19^2\times0·2)+(11^2\times0·1)+(5^2\times0·1)}{0·6.}}$$

$$=\sqrt{\frac{101·4}{0·6}}=13.$$

The values of this varying current, expressed in terms of the corresponding unvarying current, as deduced from data got from the voltameter and the balance, are 11·7 and 13 respectively. The case supposed is not, it is true, one likely to occur in practice, but it has served the object of showing, in an elementary and unmistakable way, that with a varying current the two methods of measurement must give different results, and that the difference may be very great indeed.

If the current shown in Fig. 4 had been taken and the voltameter had indicated a current of 1 ampere, the balance would have indicated a current of 1·11 amperes.

A glance at Fig. 6 shows that the indication of the balance is independent of the direction in which the current is sent through it; it can, therefore, be used for an alternating current with which, unlike the voltameter, its readings will be the same before as after commutation. As the commutation of an alternating current to make it flow always in the same direction is rarely possible, such currents can, as a rule, only be measured by means of some form of balance.

The legal meaning of the word "ampere" is thus indeterminate except in two cases, those of the unvarying current and of the alternating current.

There are really two amperes, an electro-chemical ampere and an electro-dynamic ampere; call these for the moment the (*c*)-ampere and the (*d*)-ampere respectively.

An unvarying current can be measured equally well by either, as the number expressing the value of the current is the same in both cases. An alternating current measured in (*c*)-amperes would always have the value zero, it is therefore measured in (*d*)-amperes.

An unvarying current may be imagined to begin varying a little, and these variations to increase until it developes into an alternating current. The ratios of the values of this current, as measured by the two methods, vary from 1:1 to 1:∞, and unless the curve representing the value of the current at each instant in amperes be known, for about the instantaneous value of the current there is no ambiguity, the true ratio cannot be determined except by actual measurement. This state of affairs is unsatisfactory, and may prove very inconvenient.

A new kind of ampere having been introduced, it is interesting to speculate what new kind of meaning may be attached to the word "coulomb."

It has been said, when speaking of the unvarying current, that a coulomb is as definite a quantity of electricity as 1lb. of water is of water; a current in a conductor has been conceived to be a carrying of electricity across a section of that conductor, so that the value of a current may be taken to mean the quantity of electricity carried across the section in a given time. Simple and definite as this may seem, its interpretation, if applied to the alternating current, really depends upon how far the reader's mind is influenced by mathematical conventions.

A simple example may show this to be the case. When an Exhibition is open it is customary to publish a statement of the number of people that have passed the turnstiles each day; if an individual leaves the Exhibition and comes in again on the same day, he is reckoned as two people passing in; with this definition it is quite clear what is meant by 10,000 people having passed the turnstiles. But there is another way of looking at the matter. The direction in which a person crosses a turnstile to go in is the exact opposite of that he takes to go out. If the *direction in* is reckoned + and the *direction out* is reckoned −, since everybody who passes in after the opening of the Exhibition in the morning must pass out before the closing in the evening, the total number of people that would pass the turnstiles on the day in question is 0.

Two statements, therefore, to record the measurement of a well-understood physical phenomenon may be 10,000, or 0, the proper number depending simply upon definition.

Returning now to the alternating current shown in Fig. 3, it is uncertain, without knowing the convention sanctioned by authority, whether it conveys, say, 10 coulombs per second across any section of the conductor or 0 coulomb. Suppose, however, the current commutated, and measured by the voltameter to be 10, on the balance it will be over 11. Do then 10 or 11 coulombs pass per second?

This seems very much like asking—if water flows in an unvarying stream over the top of a weir, but breaks into drops so

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as to flow into the river below in an intermittent current—can two tons of water flow into the stream below for every one ton that flows over the top of the weir?

From a legal point of view such questions cannot be answered until further definitions have been furnished by the Board* of Trade. The difficulty may or may not be a grave one, the question has rather been raised to show the importance of the method of measurement employed, in any case, being stated now that the ampere has at least two meanings.

Much greater difficulties, however, than those of mere definition arise from effects produced in certain circuits, when carrying, varying, or alternating currents, due to the property known as self-induction, which must be considered at some length.

[ERRATUM.—In the references to Fig. 5 of this article on p. 171 of our last issue, for M T read L O.]

(To be continued.)

WELDING BY THE ELECTRIC ARC.

The Benardos system of electric welding consists, as many of our readers are aware, in the use of an electric arc formed between the metal to be operated upon, and a carbon manipulated by the workman. As originally used and described,* the process did not appear to be very promising. It might be thought that an arc would be a difficult tool to handle, and the accounts of early experiments seemed to suggest that its usefulness would be confined to the repair of large pieces of work. The arc system of welding has, however, received the careful attention of Messrs. Lloyd and Lloyd, of Coombs Wood Works, Halesowen, near Birmingham. This firm are the largest manufacturers in Europe of butt-welded, galvanised, wrought-iron gas, steam, water tubes and fittings. It may be mentioned that they stock about 200 miles of finished tubes, and the manufacture of ten miles a day is an ordinary rate.

The history of the application of the Benardos process to this manufacture is interesting. Messrs. Lloyd and Lloyd were the first to introduce the system of gas welding for the manufacture of large iron tubes, the metal being heated locally by a

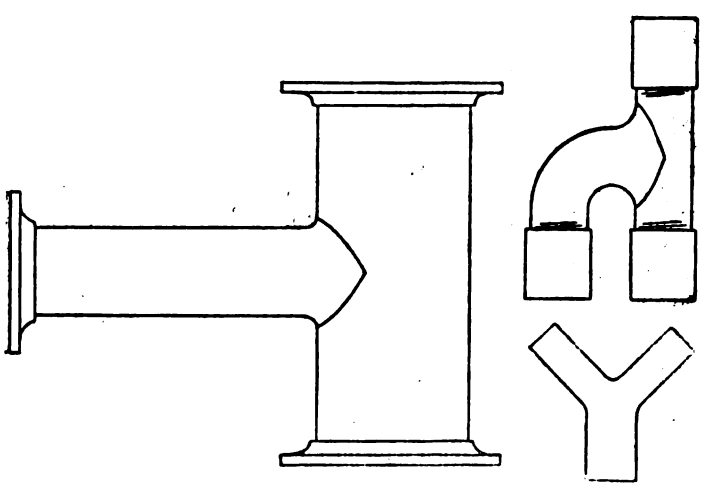

FIG. 1.—Samples of Fittings made by Electric Welding.

powerful blow-pipe. This mode of heating the metal allows a local application of the heat which is impossible upon a smith's hearth, and also permits much thinner and larger pieces to be handled. In fittings, that is to say, bends, tees, and elbows, &c., this is particularly noticeable. A diameter of six inches used to be the limit for wrought-iron work, and even these could only be made by a few highly skilled workmen. Larger sizes could only be produced, at an almost prohibitive cost, from iron of $\frac{5}{8}$ or $\frac{3}{4}$ thickness. By the electric process, fittings of 12 in. diameter $\frac{5}{16}$ thick, have been successfully made and tested to 800lbs. per square inch.

* *The Electrician*, Vol. XX., p. 58.

The process of arc-welding resembles soldering in some respects, but it is essentially the same as that of "burning-on," with two important differences, viz., that instead of relying on the heat contained in a quantity of molten metal, which is but a poor vehicle seeing its low specific heat, a continuous application of heat from a never-failing source is provided; and this heat is in the most efficient form, since it is at the highest temperature known to science. The simple "burning-on" process is rarely used except for the repair of castings. The gas-welding process made it possible to work thin metal, the patented process of gas-welding of Messrs. Lloyd and Lloyd being used under license for the manufacture of corrugated flues. So similar is the electric arc process, that but for the intense light and fragrant smell of ozone it would be easy for any intelligent spectator to mistake the simple carbon-holder for a blow-pipe, and the roaring arc for a blow-pipe flame which appears to shoot out to the work.

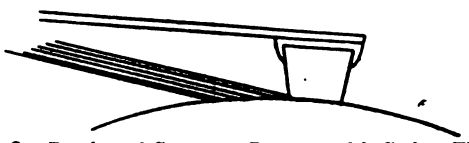

FIG. 2.—Brushes of Crompton Dynamo with Carbon Tip.

A compound Davey-Paxman horizontal engine 12¾in. and 20in. × 24in., giving 100 I.H.P. at 100 revolutions per minute, is employed to drive three Crompton dynamos of the ordinary pattern. These are respectively marked 140 volts 150 amperes, 150 volts 200 amperes, and 150 volts 200 amperes. They run continuously during working hours, and, but for the higher voltage, differ in no way from Messrs. Crompton and Co.'s ordinary patterns. Carbon-tipped brushes (Fig. 2) are used, as in several central-station dynamos of this make. The carbon prism is held by a stout copper plate, and effectually stops sparking with variable loads, while the bulk of the current is collected by the ordinary plate brushes just behind it.

The dynamos working in parallel are used to charge a large set of accumulators. There are 1,800 cells of the Planté type

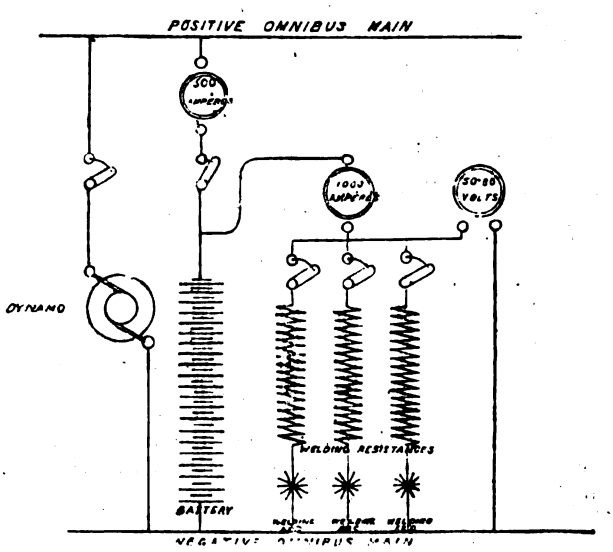

FIG. 3.—Diagram of Connections of Dynamos, Accumulators, Instruments, Resistances, and Arcs.

manufactured by Messrs. Lloyd and Lloyd, under the Benardos patents. The plates, 9in. by 7in., are constructed of zigzag strips of lead burned together by the arc process, and formed in a special manner. The appearance of the cells was very satisfactory; in the two years during which they have been at work, it has not been necessary to replace a single plate. The Planté type is suitable for this work, since very small storage capacity in ampere-hours is needed, the function of the battery being simply that of a fly-wheel. It frequently gives a current twice that of the dynamos, and is capable of yielding a very heavy discharge, which, even though lasting for a very short time, would ruin a pasted plate.

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In addition to the accumulators, regulating resistances are employed (Fig. 3), both in the instrument room, and beside each bench, every workman having a switch close at hand to enable him to regulate the current to suit the job in hand. In the instrument-room, a number of voltmeters and ammeters show the performance of the dynamos and the current used in the shop. The usual current for each arc is about 150 amperes at 70 volts.

With the exception of the patent pipe-welding machine, to which we shall allude presently, the whole of the electric work was being done with the simple tool illustrated in Fig. 4. This consists of a wooden handle through which a flexible cable is passed, a metal rod with a split clamp for holding a carbon, and an iron shield faced with asbestos to protect the hand. As a rule, the carbon is the negative pole, while the positive lead is clamped to the table or to the work. This allows a longer arc to be formed, since it is a well-known feature of the electric arc that the positive pole volatilises, and in the present case the vapour of the metal greatly assists in maintaining the arc, which may be drawn out to a length of six inches with a flame 1½ in. in diameter. An arc of two to five inches is generally employed, the longer distance giving a more regular heating effect. The workman generally leaves the current on and places the tool on a support or on the bench. To start the arc he touches the metal, generally in a comparatively cool part near the portion being worked, and in a few seconds the metal is raised to working heat. Ordinary welds are made by placing a piece of iron or steel, weighing from one to two ounces, on the work ; the arc is allowed to play

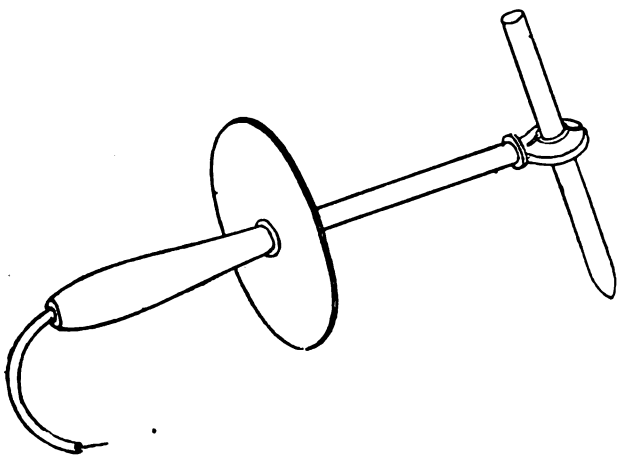

Fig. 4.—Messrs. Lloyd and Lloyd's Patent Carbon Holder.

until the metal begins to run, the degree of heat being carefully adjusted to the particular kind of job ; the arc tool is removed and the portion is hammered in the usual way. Without the hammering, the joint, if made at all, would be very crystalline. It is possible that on the occasion of our visit the men were showing off their skill; but one group of three, engaged on a wedge weld of a large pipe-fitting, while not working harder than ordinary piece-workers, used the arc tool for 12 to 14 seconds, which sufficed to bring the bit of iron and the work on which it was laid to working heat ; 5 to 6 seconds were spent in hammering, and the intervals during which the tools were changed seemed to occupy less than one second. Some 2in. to 2½in. of seam were welded at each heat, and thus about three heats were made in a minute, the work never being removed from the anvil. Hardly any slag or scale was to be seen, the fact that the work was made the positive pole probably created so copious a cloud of iron vapour that the oxygen of the air could not reach the heated surface. For some purposes, such as lead burning, the arrangement is reversed, and the carbon is made the positive pole, the metal in this case probably receives most of the heat by radiation from the carbon. While in the ordinary process of lead-burning great cleanness of surface is essential, with arc-welding the ordinary grey condition of the metal seems to offer but little obstacle.

To heat a considerable surface something more than a long and powerful arc is required. A very interesting pipe-welding machine has been built for making tubes of thin sheets, and in this a mechanical motion of the carbon produces the desired effect. The carbon-holder is illustrated in Fig. 5. A vertical spindle arranged with a feather and depressing lever, exactly like that of a drill, carries a slide at its lower end, and to this, clamped by a bolt, is attached a carbon-holder which can be set with any desired eccentricity. The spindle, which needs but little power to drive it, is mounted on a carriage, and a crank-pin, capable of radial adjustment on a disc, moves the carriage to and fro by means of a connecting rod. Tubes of about 9in. diameter and 2ft. length were being made up from thin sheet. The carbon described a circle of about 2½in. diameter, making 300 to 400 revolutions a minute, while the carriage had a traverse of about 4in., making about 30 strokes a minute. The motion was given by a small motor mounted on the machine, and was controlled by a switch. The tube was placed on a mandril, having a fire-brick lump below the arc. The tube being slipped on, the carbon-holder was brought down to start the arc, and was then raised about three inches and set spinning. The end of the arc was at first confined to one spot on the work, but the metal becoming hot it soon spread out, and after a few seconds described a larger circle than the carbon itself. The rotary motion of the carbon, combined with the traverse, covered some 15 square inches. The current used was from 250 to 300 amperes. An Aron meter registered the whole quantity. Pieces of steel were laid on the seam, and

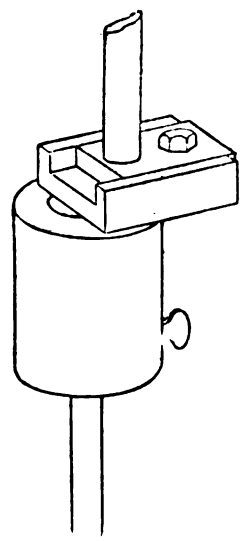

Fig. 5.—Messrs. Lloyd and Lloyd's Patent Mechanical Arc Heater.

when working heat was reached, the arc and the motor associated with it were shut off, the tube shifted longitudinally a foot or so on to the mandril, and a Player hammer rapidly worked up the weld. The hammer was run by another electric motor mounted on the top of the machine, and was controlled by a third switch. These switches were mounted on a sloping metal screen, which protected the smith from the intense heat, but allowed a good view of the work through a red glass pane. The other men were provided with similar glass screens, either fixed to the machine, or held in the hand ; or wore suitable spectacles. Wooden partitions or boxes are arranged round each bench, and a large red glass window is provided in each. A passer-by is thus protected from an accidental glimpse of the powerful arcs. The same men are now engaged in welding who were at work on the process when first started. They are allowed to work in their own way, and are not subjected to constant instructions, as so often happens when a new process is introduced. No difficulty has been found in getting men willing to learn to handle the carbon, and we understand that no welder has ever left the work, or suffered in health or sight.

Hydraulic fittings with complicated branches set at acute angles can be easily made, the seam being welded bit by bit. The sheets from which large and thin elbows and tees are made are cut out into gussets by the use of an arc. The metal drops away like wax, leaving a somewhat ragged cut of about ⅛in. While incomparably superior to chisel and hammer work, and

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dispensing with heavy punches and shears, the chief advantages in the use of an arc for cutting appear to be that the smith who is to complete the work can cut it out as he pleases, instead of having to use sheets cut out perhaps by another man in another department; and in the facility with which cutting can be done on work *in situ*, where it is not convenient or possible to bring it into the shops.

Associated with the principle of cutting is the important application of the arc to repairing work, an application which, as we have mentioned, received early attention from M. Benardos. Steel and iron castings, facing points, locomotive wheels, pump-rods, and many other objects have been well repaired by this process. The arc is directed on the flaw or crack; the metal runs away; the arc and the piece to be repaired are so handled that a suitable cavity is formed. Sound metal is then filled in by melting down small pieces, which, if necessary, are actually welded into place, a treatment which is, of course, impossible in the otherwise analogous process of "burning on." For steel castings particularly, this process seems to be of great value, since serious flaws are often discovered only after a considerable amount of tooling has been done.

Another distinct branch of th e work is the flanging of tubes. Any thickness of flange can be welded to any thinness of pipe, or the pipe itself can be flanged out. The work is mounted in a lathe, and the arc is directed on to it while it revolves, and when sufficiently hot a presser mounted on a hinged arm completes the weld as it revolves. The job appears to be more easy than the spinning of dishes by a tin-smith.

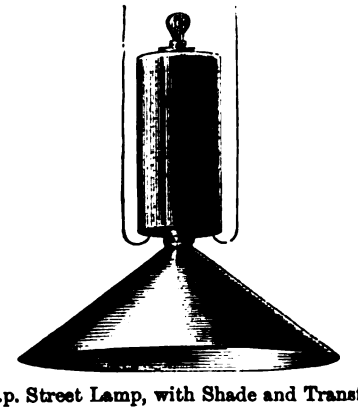
After a thorough experience of gas-welding, Messrs. Lloyd and Lloyd have no hesitation in saying that with two years' experience as sole licensees of electric welding on the Benardos system, the arc-work can be done at one-fourth of the expense of the blow-pipe. This result is largely due to the improved appliances which have been invented by Mr. Henry Howard, of Stonehouse, Kidderminster, the acting partner of the firm at Coombs Wood. Of the quality, it is only sufficient to say that a large quantity of hydraulic fittings are made; and though they do not generally run to more than two inches diameter, they are in all cases tested to high pressures from 1,000lbs. to 3,000lbs. per square inch. Messrs. Kirkaldy's tests of bar welds are highly satisfactory, and the range of possible applications of the process seems to be very wide.

If only because the bulk of the work done by arc-welding, and certainly all those examples which we have mentioned, would not be suitable for the butt welding of the Thomson process, a comparison would be unnecessary. The latter possesses undoubted advantages for welding wire, rods, and bars. It has induced some manufacturers to change their designs in order that its full advantage might be gained. What it could not do can be done by arc-welding, and there are but few jobs which can be done by neither. A most important consideration is the small cost of plant for the arc system. The dynamos are not expected to give the full working current, and their load factor is high. The batteries are not expected to have any considerable storage capacity. The leads are moderate in size. The volts are practically constant, and lights may be run off the same circuit. The ordinary mode of applying the heat is the simple handling of a tool worth a shilling or two. To educate men to use a blowpipe was not difficult, and the change from the blowpipe to the arc is hardly any change at all.

On Monday last a large party of engineers and representatives of the Press left the fogs of London by a special train, and after having luncheon at Birmingham, where the sun was shining brightly, visited the Coombs Wood Tube Works. In the handsome mess-room was a display of samples of work done, including very large bends and other fittings, flangings, repaired forgings and castings, and Kirkaldy test pieces. The works were then visited, and the processes of electric welding and other work were watched with great interest, a large pile of dark red glass screens having been provided for the visitors; more than one of whom, however, suffered afterwards from accidental glances at the arcs or careless use of the screens. The extensive gas-tube department, stores, and fitting-making shops were inspected, and all questions were answered and information was freely given to inquirers by the members and the staff of the firm.

A TWO-THOUSAND VOLT STREET LAMP.

Street lighting by alternate current has for some time past presented considerable difficulties. In most cases transformers are arranged in the houses, and the stations have high-pressure leads only. To run incandescent lamps it is, therefore, necessary to employ transformers and a system of low-pressure



A 32-c.p. Street Lamp, with Shade and Transformer.

leads. Messrs. Swinburne and Co. have brought out a lamp which contains a small transformer, and is connected direct to the high-pressure system without any low-pressure leads. A 32 c p. lamp with protector is arranged under a large enamelled iron shade, which is secured to the base case of a small transformer.

A NEW FORM OF ELECTRIC MEASURING INSTRUMENT.

The accompanying illustration shows an electrostatic instrument recently brought out by Messrs. Swinburne and Co. for experimental work in connection with alternate currents. Instead of quadrants there are two pairs of half discs, so that the angle of deflection can be large. The needle consists of two half discs fastened on a metallic arbor. It is held by top and bottom suspensions. One disc is in the upper box and the other in the lower. The boxes are connected, not to ordinary terminals, but to highly insulated flexibles, as the ordinary

An Electrostatic Volt- and Watt-meter.

terminals are not suitable for high pressures. This instrument can be used as a voltmeter, or it may be connected up to measure power by any of the various methods involving two readings. It can also be connected up as a direct-reading wattmeter. The electro-magnet below the boxes acts on a copper drum, and renders the instrument dead beat. This magnet is excited by a cell. For large readings the torsion head and pointer on the top of the instrument are used; but for small readings the mirror is employed. Four of these instruments have been lent to Dr. Fleming to carry out experiments on the measurement of power by various different methods.

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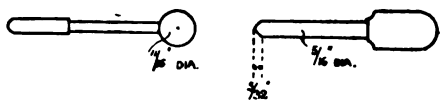
ALTERNATING SPARKING DISTANCES.

The following tests of the sparking distances of 20,000 alternating volts between two balls, a ball and a sharp point, and two sharp points, have kindly been sent us by Mr.



Details of Electrodes.

Ferranti. The dimensions of the balls and points are given in the accompanying sketch.

2 Balls $\frac{11}{16}$ inches diameter (about 18mm.).

Distance apart.	Result.	Remarks.
Inches.		
$\frac{1}{4}$	Over directly.	
$\frac{5}{16}$	" "	
$\frac{11}{32}$	" "	
$\frac{3}{8}$	Over after 2 minutes	
$\frac{13}{32}$	Not over.	Went over when the 2,400 V switch was put off *sharp*.
$\frac{7}{16}$	" "	" " "
$\frac{1}{2}$	" "	When switch was put off *slowly*.
$\frac{9}{16}$	" "	" " "
$\frac{5}{8}$	" "	

Ball and Point.

Inches.		
$\frac{5}{16}$	Over directly.	
$\frac{7}{16}$	" "	
$\frac{1}{2}$	" "	
$\frac{9}{16}$	" "	
$\frac{5}{8}$	" "	
$\frac{3}{4}$	Over.	Visible discharge before going over.
$\frac{7}{8}$	"	" " "
1	"	" " "
$1\frac{1}{8}$	"	" " "
$1\frac{1}{4}$	Over after 1 minute.	" " "
$1\frac{3}{8}$	Not over.	Visible discharge from point, but did not go over after two minutes.

Two Points.

Inches.		
1	Over directly.	Discharge as above.
$1\frac{1}{8}$	Not over.	Discharge but not over until 2,400 V-switch was put off (on 2 minutes).
$1\frac{1}{4}$	" "	" " "
$1\frac{3}{8}$	" "	" " "
$1\frac{1}{2}$	" "	No discharge, but went over when switch was put off.
$1\frac{5}{8}$	" "	" " "
$1\frac{3}{4}$	" "	Nothing happened.

PHYSICAL SOCIETY.

At the meeting of the Physical Society on the 18th inst., a "Note on Interference with Alternating Currents" was communicated by Mr. M. H. Kilgour. Whilst studying Dr. Fleming's Paper on "Some Effects of Alternate Current Flow in Circuits having Capacity and Self-Induction," the author constructed some additional curves. He was thereby led to investigate whether the serious rises of pressure produced by adding capacity would occur over considerable ranges of capacity, or whether they would only take place when the capacity was nearly equal to a particular value. Taking the case of a condenser of capacity C farads, in series with a circuit of resistance R ohms, and inductance L henrys, he showed that the maximum value of λ (the ratio of the pressure across the condenser terminals to that across the condenser and inductive resistance) is obtained when

$$C = \frac{L}{R^2 + p^2 L^2} \quad \ldots\ldots\ldots \quad (1)$$

where $p = 2\pi$ times the frequency. The maximum of λ being given by the expression

$$\Lambda = \frac{\sqrt{R^2 + p^2 L^2}}{R} \quad \ldots\ldots, \quad (2).$$

If we take the values R=10, and $p = 2\pi$ 1,000 curves plotted from equations (1) and (2) between C and L, and between Λ and L had been drawn. The C L curve rises to a very sharp peak at L=·0015 and falls rapidly. That between Λ and L starts horizontally and bends upwards, and approximates to an inclined straight line values of L greater than 0·002; when L=0·1, Λ=63. Considering the question of the range of capacity with which a given rise of pressure can occur, it was pointed out that when the values of L, R, and p are such as to make a large rise possible, a rise exceeding a moderate value can only be obtained for values of C differing little from that given by equation (1). On the other hand, when the circuit is such that the maximum rise possible is not large, then a rise exceeding a given moderate value can be obtained over a much wider range of capacity. Hence the author concludes that the larger the possible rise, the smaller is the probability of a serious rise occurring. The effect of shunting the condenser by a circuit of resistance r and inductance l is next dealt with in the Paper, and the values of C which make Λ a maximum determined, as well as the maximum value Λ can have. Subsequently the author examines whether the practical case of an alternator feeding a transformer through a concentric cable may be simplified without introducing serious error by assuming the capacity concentrated at either end of the cable, and concludes that in ordinary cases little error will be thus made. In an experiment made with a 100-kilowatt alternator, $\frac{3}{4}$ mile of 37/15 concentric cable, and an 18-kilowatt transformer, a rise of $\frac{1}{4}$ per cent. was found to occur at the terminals of the alternator when the cable was connected. Putting on the transformer, unloaded or loaded, produced little change in the rise of pressure; this in all cases being between 0·2 and 0·3 per cent.

DISCUSSION.

Dr. SUMPNER asked whether the conclusions as to the range of capacity with which a given rise of pressure was possible was true for small rises such as occur in practice. Cases where the maximum possible rise was of the order 63 were not likely to occur at ordinary frequencies. The highest rise he had ever known was 11. He thought the times constant of the inductive coil chosen, viz., one-hundredth of a second, was very large. In circuits containing iron it was practically impossible to get such large time constants, for the power spent in the iron increased the effective resistance. Referring to the narrow range of capacity within which large rises were possible, he pointed out that such cases were found in Hertz's resonators where the rises were immense, but to obtain them the adjustments had to be very accurately made.

Dr. S. P. THOMPSON said he regretted that Prof. Fleming was not present, for he had recently investigated Hertz's experiments, and had obtained curves very similar to those got for the Deptford main. The curve between Λ and L was very interesting. It was, in fact, a curve between the secant of the angle of lag and L, as could be seen from formula (2). In practice, one would be working on the lower portion, and hence the rises would be small.

Mr. KILGOUR explained that in the Paper his first object was to show that the product of the range of capacity between which a rise greater than a given value would occur and the maximum possible rise was approximately constant for different circuits. Secondly, he wished to prove that the capacity of concentric cables could be assumed to be localised at either end without introducing much error in the rises of pressure calculated therefrom.

Dr. THOMPSON, speaking of nomenclature, regretted that the word "inductance" should be used sometimes for L and at other times for Lp, and thought its meaning should be restricted to the latter.

Prof. PERRY said a name was needed for "coefficient of self-induction." "Resistance" was practically independent of frequency, and "inductance" should have no reference to frequency.

Dr. SUMPNER thought it important to have a name for Lp, for that quantity came into calculation most frequently. He would have preferred that "inductance" should mean Lp; but Mr. O. Heaviside, who introduced the term, had used it for L.

The PRESIDENT remarked that some time ago Dr. Sumpner and himself felt the need of a name for Lp, and thought of using "inductance"; but on referring to Mr. Heaviside's articles found it used for L.

Dr. C. V. BURTON asked whether the word "self-induction" could not be used as an abbreviation for "coefficient of self-induction."

Dr. THOMPSON pointed out that this word already had a meaning, viz., L multiplied by current.

Dr. BURTON then suggested that "inductivity" might be applicable.

Dr. THOMPSON said the word "impedance" was also used ambiguously; for the sense in which Dr. Lodge used it in his "Modern Views of Electricity" was not the same as the vector sum of R and Lp.

Prof. PERRY recalled the fact that "impedance" had been defined by the Committee of the British Association as the ratio $\frac{\text{effective voltage}}{\text{effective current}}$.

Dr. THOMPSON said this definition was only applicable to periodic currents, and not to intermittent or transient ones.

The PRESIDENT said he understood the first object of Mr. Kilgour's Paper was to inquire whether the dread of rise of voltage occurring when concentric mains were used need exist. When Dr. Fleming's Paper was read the general idea was that concentric cables were dangerous. In the discussion on it he, amongst others, had pointed out that the chance of a large rise of pressure was not a serious one. Mr. Kilgour had now shown that the range of capacity over which a particular rise could occur is inversely proportional to the maximum rise possible in the particular circuit. When the circuit was such that a large rise was possible, the probability of any serious rise taking place was very small, hence the fears of large rises were more or less unfounded. The second part of the Paper was to show that ordinary problems on concentric cables could, in practice, be treated with sufficient accuracy by assuming the capacity localised at either end of the cable, instead of distributed along its length.

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THE THEORY OF THE RUHMKORFF COIL.*

BY M. COLLEY.

The Ruhmkorff coil has been the object of numerous researches bearing almost entirely upon the phenomenon of luminous discharge; but the author has studied from an experimental and theoretical point of view the electric phenomena which are produced on opening the primary circuit. The ends of the primary were joined to the plates of a condenser with a maximum capacity of 5·3 microfarads, and the circuit could comprise at will several supplementary coils of low resistance and high self-induction. The coil had no iron core. The image of the spark was thrown on to a revolving mirror. An ordinary Geissler tube was employed, and it was covered with black paper, except along a narrow longitudinal strip, which was only broken at the conical portions comprised between the broad and narrow parts of the tube. The tube was placed vertically before the mirror, which revolved round a vertical axis. The primary current was interrupted at the moment when the mirror was turned towards the observer. The condenser of the apparatus was replaced by one formed of 300 sheets of tinfoil, separated by paraffined paper. The self-induction of the external coils was considerably greater than that of the primary coil alone, their presence had the effect of retarding and regulating the discharge.

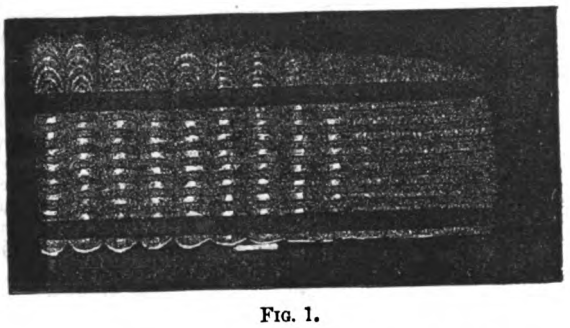

FIG. 1.

When the secondary circuit was open, the spark gap being from 30 to 40cms., the discharge shown in Fig. 1 was obtained, a large inductive coil and all the available capacity being placed in the primary circuit. A series of equidistant vertical bands, separated by less brilliant ones, are to be seen ; the difference of appearance becomes gradually less pronounced ; and everything melts into a train of light, the brightness of which is steadily diminishes. The horizontal bands correspond to the striæ visible in the narrow part of the tube ; the movement of the striæ gives them this wave-like appearance. The black bands are caused by the break in the slit cut in the black paper cover. At the lower end (+electrode) a curious appearance, indicating the presence of layers in rapid motion, is noticeable, the colour is pale blue, and the phenomenon allows one to see for certain at any moment the direction of the discharge.

A study of Fig. 1 will show us that we have to do with two superimposed currents, one dead-beat, the other periodic ; it is the latter which causes the horizontal band. The train of light indicates that the first discharge lasts after the periodic one has become sensibly equal to zero. Finally, as the fringes have no dark portions, it follows that the total discharge is never annulled, or, more exactly, does not fall to the minimum value below which a discharge ceases to take place.

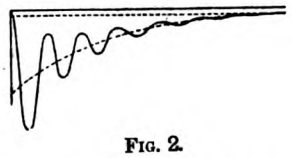

FIG. 2.

In Fig. 2 are shown the variations of the discharge. The dotted curve is the dead-beat portion, the full curve the periodic portion ; the dotted straight line shows the minimum value necessary to ensure a discharge.

If we employ a smaller coil with a 2cm. spark gap, somewhat different phenomena are observed, which may be interpreted as follows :—The dead-beat current, which depends solely upon the nature of the secondary circuit, diminishes more rapidly, whilst the periodic current, which depends only on the primary circuit, remains much the same. The periodic portion is, therefore, predominant.

When the secondary circuit is open we can investigate at the same time the strength of the discharge and the difference of potential. Two batteries of about equal capacity, each composed of four Leyden jars, had their external coatings connected to the terminals of the induction apparatus. Their internal coatings were joined together through the Geissler tube. The discharge which passes through this tube may be considered as having at every instant the same value as that which traverses the secondary coil. It was possible by means of a well-insulated commutator to cut out all but one of the Leyden jars in each battery, and the primary external inductive coils were replaced by zigzag resistances. With the large Ruhmkorff coil the discharges shown in Figs. 3, 4, and 5 were obtained.

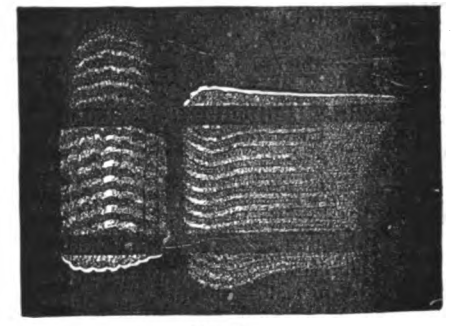

FIG. 3.

FIG. 4.

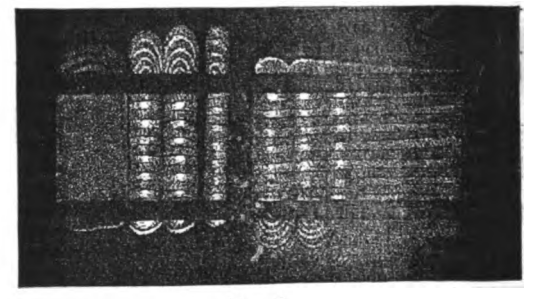

FIG. 5.

In the case of Fig. 3 the primary circuit did not contain any external inductive coil, but only a zigzag resistance of 2 ohms. The discharge attains a maximum, changes sign, and then tends to zero.

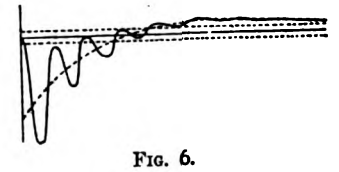

FIG. 6.

In Fig. 5 the self-induction of the primary was increased. The rose-coloured undecided streak on the left was due to a too slow rupture of the primary current (the spark was very powerful). Fig. 6, which shows some curves derived from an equation given by the author, explains all the results.

In the previous cases we were close to the limit where the dead-beat factor becomes periodic. If we suppress three Leyden jars we obtain the discharge shown in Fig. 4 ; the fringes are about twice as broad as in the previous case, which was to be expected, since the capacity was only one-fourth.

Other phenomena were observed, of which the theory remains to be deduced. With four Leyden jars we can, by breaking the primary current, more smartly obtain oscillations in the secondary. The same result is obtained without a commutator by using more

* *Journal de la Société Physico-Chimique Russe. Wiedemann's Annalen*, 1891. Abstract of a translation in *La Lumière Électrique*, November 14, 1891.

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Leyden jars. When low capacities are employed, isolated luminous bands separated by dark intervals are obtained, and the discharge only retains for a very brief period sufficient strength to traverse the tube. With a small coil the results are much the same, the secondary discharge is weaker, and the influence of the primary is greater.

In conclusion the author asserts that his experiments completely verify his theoretical results; the movement of electricity in the secondary is, therefore, well represented by the formula obtained by him. Moreover, and this point is very important, the phenomena which are produced in ordinary apparatus differ in no way from those investigated by the author. For example, the suppression of the external coils in the primary only has the effect of accelerating the discharges and of rendering them less regular. The capacity of the coils themselves replaces that of the Leyden jars employed in the experiments, and allows us to obtain oscillatory discharges even with small apparatus, in which the ends of the secondary are insulated.

It is no use to think of employing an electrometer in the direct investigation of such rapid variations of potential; but the author has discovered the following phenomenon, and on investigation it may be found applicable. If we light a gas flame at the end of a slightly contracted glass tube and introduce a metallic wire into the tube, the flame jumps up sharply every time the wire is charged. If we connect the wire to one pole of a Ruhmkorff coil, the other pole being to earth, we see in the mirror an oscillation of the flame, but it is so fantastical and irregular that the author has up to the present found it impossible to make anything out of the phenomenon.

LEGAL INTELLIGENCE.

Savory and Moore v. London Electric Supply Corporation.

In the Chancery Division of the High Court of Justice, on Friday, Mr. Justice Kekewich gave judgment in the case of Savory and Moore *v.* London Electric Corporation, which was an action to restrain the defendants, who occupy buildings adjacent to the plaintiffs, from using their buildings as a station for converting the electric currents generated by them at extra high pressure, or as a station for the distribution of electric currents at extra high pressure, and from storing or using transformers and electric cables at the said premises, and from using or allowing to be used the said premises as a converting or distributing station in connection with their supply of electricity.

Mr. Warmington, Q.C., and Mr. Vernon Smith appeared for the plaintiffs; and Mr. Moulton, Q.C., and Mr. W. F. Hamilton for the defendants.

His LORDSHIP, in delivering judgment, said that there was now no imminent danger against which the plaintiffs were entitled to protection was clear beyond dispute; but that there would be no such danger in the future was not equally clear, because defendants' plans above the basement were wanting in precision, and a disposition to be guided by circumstances and the exigencies of trade formed an awkward factor in the sum of possible results, into which, of course, inexperience and carelessness largely entered. The powers and, therefore, the dangers of electricity could not be regarded as known even by scientific men with sufficient accuracy to justify a positive statement respecting possible results in hypothetical circumstances, especially when the locality was in the heart of a crowded city. He had thought that the parties might have come to an arrangement; but the plaintiffs required, as they were entitled to do, a decision on the merits; and, therefore, he must have regard not to the present but to the past. To the claim of the plaintiffs the defence was merely that the action was premature. The defendants said that if the plaintiffs had waited a little while and had given only a slight consideration to their reasonable assurances, they would have been satisfied; that what had happened before would not and could not recur, and that any shortcomings of the past would be avoided in the future. The evidence conclusively proved that the operations of the defendants as conducted prior to November 15, 1890, were of imminent danger to the plaintiffs, and this was due to two causes, singly or in combination—first, the inherent, though latent, danger of the works; and secondly, the neglect of precautions. It followed that any injury to the premises would have been actionable, and seeing that the injury, if it happened at all, was likely enough to be serious, alarm was natural and justifiable. That it was still natural after the defendants' premises had been gutted on November 15, 1890, was sufficiently clear; but was it justifiable? If it was justifiable before plaintiffs communicated with the defendants, did it remain so after that time? To answer that question it was necessary to examine the facts. Within a short period there had occurred on the defendants' premises two fires traceable to the causes he had mentioned. One of the fires was soon extinguished, and, so far as the plaintiffs were concerned, it did no harm. The other, which occurred on November, 15, 1890, was of a more serious character, more alarming, and more destructive. It destroyed the defendants' building, and the injury extended to the plaintiffs' premises. Who could blame the plaintiffs for thinking that this incident was likely to be repeated with disastrous consequences, and that it behoved them to take measures for the protection of their property? Giving them credit for such an acquaintance with the defendants' operations and their conduct of business as might reasonably be presumed, they would expect that, with as little delay as circumstances permitted, the defendants would again make the building available for supplying their customers, and that the conditions of the restored building would not substantially differ from those just destroyed. The experienced past and the anticipated future therefore combined to make the plaintiffs apprehend danger, and to urge them to take active measures to prevent a repetition of such danger. This they did promptly and prudently. They issued a writ and communicated with the defendants' solicitors in a temperate letter deserving of commendation. In that letter they asked for an undertaking in the terms of the injunction which they claimed by their writ. He held that the plaintiffs were right in asking for such an undertaking. It did not appear that the elements of danger from fire had been or would be completely removed, and therefore he granted the plaintiffs an injunction in the terms in which they had said they were willing to accept an undertaking, with costs.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December* 11, 1891.

The Eickemeyer Motor.—Another gearless motor has recently attracted attention in electrical circles. This is the Eickemeyer machine, which was really the first of the gearless type; but it has kept very much in the background until within the past few weeks. Mr. Eickemeyer's plan is to use a single large motor, supported on a truck instead of on an axle, and driving both axles by means of a crank shaft and connecting rods. In addition, the wheels on the car are of considerably smaller size than usual, so that the requisite car speed can be obtained without too great a reduction of armature speed. The purpose of this peculiar arrangement is by cushioning the weight of the motor to prevent damage to the armature from shocks. Mr. Eickemeyer is especially fearful of the danger of injuring the armature when it is placed directly on the car axle. The thing to be criticised in this device is the severe strain imposed on the crank shaft by this very vibration. Several Eickemeyer cars are in operation in Lynchburgh, Va., and run with a considerable degree of success, although private reports from that point indicate that there have been many repairs. The Western Electric Company, of Chicago, is manufacturing a number of these machines, and they will shortly be at work on a more extensive scale.

Storage Battery Traction.—Another storage battery traction scheme is afoot; this time it has taken the form of a company, with Mr. Conrad L. Jordan, a gentleman well-known in financial circles, at its head, and with $500,000 capital, to exploit the McDougall system. Mr. McDougall is one of the early workers in the electrical railway operations of the Edison Company; and, so far as can be ascertained, has a very good form of motor truck. The batteries, however, are the indeterminate feature of this scheme. Up to the present he has been using a large variety of cells with tolerable results, but there is nothing sufficiently radical in it all to warrant any great amount of faith in the undertaking.

Electrical Litigation.—In legal circles things of electrical interest are, first, the trial on appeal of the incandescent lamp case, which will probably take place the first of the year; and, second, the "feeder" and "main" suits, two in number, instituted by the Edison Company to substantiate their patent rights to the feeder system. These have been very sharply called in question, and the coming trials will be of considerable interest and importance. The result of the incandescent lamp decision has not as yet been the suppression of the smaller manufacturers or any compromise, and the opinion is freely expressed that it will be a long time before the Edison Company is able to collect any damages from alleged infringers. The storage battery decisions of last year and this year do not seem to have led to any special results as yet. The Julian Company, in spite of the fact that it has an exclusive licence under the broad Brush patent, has been for a couple of years embarrassed in its manufacture by the Faure patent, in the hands of the Accumulator Company. So that just now both are still doing business, neither of them to any considerable extent, despite the fact that both have put on the market accumulators which compare very favourably with the best of those made abroad.

Polyphasal Generators.—At the next meeting of the American Institute of Electrical Engineers a Paper on polyphasal

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generators, by Dr. M. I. Pupin, is promised. As this is the first discussion of this subject before the Institute, it will probably attract a great deal of attention, and the mathematical contingent will be out in full force.

The Proposed International Electrical Congress at Chicago.—The proposed International Electrical Congress for the World's Fair in 1893 seems to have stirred up a considerable amount of ill-feeling in Western electrical circles. In spite of the fact that this Congress was originally proposed and endorsed by the American Institute of Electrical Engineers, that body (the only electrical organisation in the country possessing scientific standing) has been completely ignored in the matter, Prof. Gray having, through local influence brought to bear on the Government, been appointed to take charge of the matter in connection with divers other Chicago electricians. Prof. Gray is not a member of the American Institute of Electrical Engineers, and, apparently, local pressure has been brought to bear on him to stir up dissatisfaction, and to strain the relations between the Exposition authorities and the Institute. Considerable indignation has been expressed by the members of the Institute at the high-handed indifference with which they have been treated up to the present, and steps have been taken towards a proper adjustment of the difficulties. If an attempt is made to hold an Electrical Congress without the co-operation of the Institute, to gratify any personal prejudices on the part of outsiders, the result is not likely to be a shining success.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Offices not later than first post Thursday morning.*]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

THE ELECTRIC LIGHT AT SPRING GARDENS.—The tender of Messrs. J. D. F. Andrews and Co. (*see* last week's *Electrician*) has been recommended for acceptance.

MESSRS. THOS. FLEMING, SON, AND CO.—This firm have just executed an order for three 10in. double leather belts for the Gülcher Company, which are to drive their new electric light installation at the Crystal Palace. Messrs. Fleming inform us that they have at the present time belts running at the Crystal Palace which were supplied in 1881 for driving all the dynamos there, and these belts have worked continuously during the 10 years without hitch or accident.

ENGLEBERT AND CO.—We have been favoured with a copy of a very useful Calendar, published by this firm, and Messrs. Englebert and Co. courteously invite applications for further copies from users of their specialities.

THE PRICE OF GAS.—The Gas Light and Coke Company have selected the present festive season for a notification to the effect that the price of common gas of 16-candle illuminating power will be 3s. 1d. per thousand cubic feet, an increase of fourpence per thousand.

THE NATIONAL TELEGRAPH WORKS.—We have received a copy of the revised and reduced price list of the Leclanché batteries manufactured by this firm.

BULLER, JOBSON AND CO. (LIMITED).—A meeting of the shareholders of this Company (in voluntary liquidation—now Bullers Limited) will be held at 4, Waterloo-street, Birmingham, on January 14, 1892, at 3 p.m., to receive an account of the winding-up.

HUMBOLDT ELECTRIC POWER AND MINING COMPANY (LIMITED).—A meeting of the shareholders of this Company (in voluntary liquidation) will be held at the Great Eastern Hotel, Liverpool-street, E.C., on January 13, 1892, at 12, to receive the liquidator's report.

SHEFFIELD TELEPHONE EXCHANGE AND ELECTRIC LIGHT COMPANY (LIMITED).—A meeting of the shareholders of this Company (in voluntary liquidation—reconstructed under the same title) will be held at the registered offices, Commercial-street, Sheffield, on January 14, 1892, at 3 p.m., to receive an account of the winding-up.

MACHINERY AND HARDWARE COMPANY (LIMITED).—We have received a copy of the annual export catalogue of this Company, which is, as usual, full of illustrations, particulars, and prices relating to machinery and hardwares of many of the leading makers in Great Britain. This is the sixth annual edition of the catalogue, and is published in the English and Italian languages. Over 500 specialities are referred to.

MUNRO'S ELECTRICAL MANUFACTURING COMPANY (LIMITED).—We are informed that this Company have, in response to requests from their London customers, taken show rooms at 17, Princes-street, Hanover-square, W., where Mr. H. W. Hooper will represent them. The stock on show will include samples of hand-hammered and wrought arc work in electroliers, pendants, brackets, &c.

ELECTRIC APPARATUS COMPANY (LIMITED) (IN LIQUIDATION).—Mr. John Hannan (of Messrs. Broads, Patterson, and Company-1, Walbrook, E.C.), liquidator in this estate, issues a notifica, tion, dated December 17th, that a first and final dividend of 1s. 6d. in the £ has been declared, and is payable to the creditors of this Company at his offices on and after Monday, the 21st inst. (except Saturdays), between 11 and 4.

DOMESTIC TELEPHONY.—With the cheapening of telephonic apparatus consequent upon the expiry of master patents, the use of the telephone as a means of internal communication in large warehouses, hotels, &c., is likely to become fairly general. For this purpose the Ader magnetic telephone, acting both as a receiver and transmitter, is very suitable. We have before us an illustrated price list of Ader apparatus for domestic and short-line purposes, issued by Mr. G. A. Nussbaum, of 29, Ludgate-hill, London, Agent of the Société Générale des Téléphones. Ader telephones have already met with considerable vogue in this country, and from what we have heard, appear to give universal satisfaction, and providing they can compete in point of view of price and certainty with speaking tubes and rival telephonic apparatus, there should be a good demand for them. The recent installation by Mr. Langdon, Superintendent of the Midland Railway, throughout the reconstructed Adelphi Hotel at Liverpool, referred to in our "Notes" last week, and the instruments for which were supplied by Mr. Nussbaum, is described to us as a great success.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

November 23, 1891.

20,293. A. C. SNELL. Cornwall. Improvements in accumulators used for marine purposes and the like.
20,314. J. GRATTON. Nottingham. Electrical thermometer.
20,322. H. W. MILLER. London. An improved means of reproducing the indications of electrical measuring instruments at a distance.
20,328. R. KENNEDY. Glasgow. Improvements in producing alternating currents differing in phase.
20,356. W. STORR. London. Improvements connected with electric arc lamps.

November 24, 1891.

20,367. A. SHIELS. Glasgow. Improvements in couplings for electric wires.
20,389. E. T. WHITELOW. Manchester. Magnetic microphone.
20,407. R. PAPE. Liverpool. Improvements in the manufacture of a hard insulating material.
20,413. G. BAMBERG. London. Improved electrolytic apparatus, more particularly applicable for manufacturing caustic soda and other products from salt, but also applicable to other purposes.

November 25, 1891.

20,485. F. BRYAN. London. Improvements in automatic safety devices for electric circuits.
20,492. L. B. MILLER and M. W. WOODS. London. Regulating electric currents.
20,496. A. CHAMPION and J. MOSS. London. Electrical switch.
20,506. SIR C. S. FORBES. London. Improvements in microphone transmitters.
20,508. T. H. WILLIAMS. London. Improvements in and relating to dynamo electric machines.
20,524. W. W. HORN. London. An improved combined fitting for gas and electric lights. (O. Strom, United States.)
20,527. J. O. FOWLER, JUNIOR. London. Improvement in hollow cast joints for metal-armoured conductors.
20,530. A. B. W. H. COMBS. London. Improvements in and relating to ships' telegraphs.

November 26, 1891.

20,542. T. J. RICKARD. Newport. Improved incandescent lamp-holder and form or shape of incandescent lamps.

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20,545. A. R. Bennett and R. McLean. London. An improved system of telephonic exchange signalling.
20,595. F. R. Boardman. London. Improvements in arc lamps.

November 27, 1891.

20,623. W. Maxwell. London. Improvements in telephone transmitters.
20,629. C. M. Dorman and R. A. Smith. Improvements in holders for incandescent electric lamps.
20,642. E. Burgess. London. Improvements in apparatus for automatically controlling the direction of electric currents singly or in groups as for illuminating advertisements and the like.
20,678. F. Pohl, Junior. London. Improvements in electric burglar alarms.
20,689. M. Mackay. London. Improved cementitious and electric insulating compounds.
20,699. A. W. Thatcher and A. Devereux. London. A new or improved electric indicator.

November 28, 1891.

20,718. P. Pickney. Southsea. Magnetic electric boot and shoe (iron and steel) grindery.
20,748. F. Scudder. London. Treatment of and production of valuable products from sludge obtained by electrical treatment of sewage.
20,799. W. H. Blakeney. London. Improvements relating to electric call systems and apparatus for use therein.

November 30, 1891.

20,814. J. M. Richards and J. Stephen. London. Simultaneous telegraphy and telephony.
20,825. H. Edmunds and G. E. Preece. London. Improvements in the insulation or covering of or for electrical cables.
20,827. D. J. Quinn and P. W. Hoffmann. London. Improvements in electric lighting attachments for gas burners.
20,830. E. Böhm and E. Bailey. London. Improvements in electric safety lamps for mining and other purposes.
20,837. C. H. Woolf, A. E. Hayman, and A. D. R. Jameson. London. Extracting gold and silver from sea water by electrolysis.
20,840. J. Nebel. London. Improvements in armatures of dynamo-electric machines.
20,864. T. C. Hodgkinson and H. T. Tompsitt. London. A new and improved combined electro-medical apparatus coil and battery.
20,865. A. J. Eli. London. An improved electric railway system. (J. S. Gerbe, United States.)

December 1, 1891.

20,886. W. C. Martin and J. Hunter. Glasgow. Improvements in or connected with electric masthead and side lights for ships.
20,900. W. Macpherson. London. Improvements in arc electric lamps.
20,913. M. W. Dewey. London. Improvements in electrically-propelled vehicles.
20,922. C. Lütcke. Liverpool. Improvements in storage batteries or accumulators.
20,924. M. W. Dewey. London. Improvements in and relating to electric fire engines.
20,930. M. W. Dewey. London. Improvements in electrically-propelled vehicles.
20,933. M. W. Dewey. London. Improvements in and relating to electrically-propelled hose carts or carriages.
20,936. M. W. Dewey. London. Improvements in electric-heating apparatus.
20,969. T. J. Holland. London. Improvements in electrolytic tanks.
20,970. J. W. T. Cadett. London. Improvements in apparatus for measuring and registering electric currents.
20,972. G. J. May. London. Improvements in combined haulage and electric cables.

December 2, 1891.

21,018. F. T. Schmidt. Bradford. Improvements in the construction of electrically controlled arc lamps.
21,028. W. Walton and E. Lester. London. An improved gas or electric light appliance attached to a stud for the purpose of illuminating a dress shirt front.
21,033. L. Pyke and E. S. Harris. London. Improvements in dynamo machines.
21,034. P. E. Singer. London. Improvements in musical instruments operated by electricity.

December 4, 1891.

21,142. W. P. Adams. Barnes. Improvements in ceiling roses for electrical fittings.
21,143. W. P. Adams. Barnes. Improvements in electrical cut-outs.
21,154. C. S. Snell and Woodhouse and Rawson United (Limited). London. Improvements relating to electrical lamp holders.
21,173. R. H. Courtenay. Wandsworth-road. Means and electrica apparatus for promoting the growth of bulbs and other plants.
21,187. P. V. M'Mahon. London. Improvements in regulating steam engines working dynamo electric machines and apparatus for that purpose.
21,207. T. Sturgeon. London. An improved electro-motor.
21,211. W. H. Blakeney. London. An improved electric-call system and apparatus for use in connection therewith.
21,214. A. J. Boult. London. Improvements in meters or recorders of electricity. (C. Lebois).

December 5, 1891.

21,245. J. L. Clerc, J. Picard, and J. Rougeant. London. Certain improvements in electric alarm and call clocks.
21,246. J. M. M. Munro. Glasgow. Improvements in compound winding of groups of dynamos.
21,265. H. H. Brown, A. Elliot, and Chetham-Strode (Limited). London. A new or improved coin-freed device for operating electric circuits.

December 7, 1891.

21,344. J. E. Spagnoletti. London. Improvements in dynamo-electric machine commutator brushes.
21,354. H. Aron. Liverpool. Improvements in apparatus for measuring electric currents.
21,363. J. Peral. London. An improved electric lift.
21,369. H. H. Lake. London. Improvements in switches for primary or secondary batteries. (H. Müller, Germany.)
21,379. A. Bernstein. London. Improvements in dynamo-electric machines.

December 8, 1891.

21,442. H. H. Lake. London. Improvements in secondary or storage batteries. (J. L. Roberts, United States.)
21,448. S. Pitt. London. Improvements in the manufacture of filaments for incandescent lamps. (L. K. Böhm, United States.)
21,449. F. G. Howard. London. Improvements in switches for electrical purposes.
21,476. A. G. Waterhouse. London. Improvements in electric meters.

December 9, 1891.

21,505. R. Kennedy. Glasgow. Improvements in methods for producing multiphase alternating currents and in apparatus therefor.
21,541. L. Pyke and E. S. Harris. London. An improved method of mechanically strengthening dynamo electric machine inductors.
21,551. S. Pitt. London. Improvements in apparatus for the projection of electric light. (S. Harlé and Co., France.)

December 10, 1891.

21,571. J. Stevenson. London. Improvements in an apparatus for showing the principle of the utilisation of heat as a source of electricity. (V. Harbec, France.)
21,651. W. H. Dingle and J. M. Urquhart. London. A new or improved method of making and breaking electric circuits, and of apparatus therefor.
21,668. A. Marr. Manchester. Improvements in electric switches.
21,690. E. Böhm and E. Bailey. London. An improved safety switch.
21,691. E. Böhm and E. Bailey, London. A variable resistance switch.
21,702. W. P. Thomson. Liverpool. Improvements in and relating to the construction of electrodes of large dimensions for accumulators, and to supporting the same in their cells. (A. V. Kerckhove, Belgium.)
21,720. J. C. Howell and P. E. Pownall. London. Improvements in switches for regulating currents of electricity.
21,723. W. Routledge. London. Improved means of and appliances connected with electrically regulating the feed of carbon to arc lamps.

SPECIFICATIONS PUBLISHED.

1890.

18,523. Zerener. Electrically heating, &c., solid bodies. (Price 1s. 1d.)
18,556. Pierce. Electrical switches. (Price 6d.)
18,916. Aron. Measuring electric currents. (Price 8d.)

1891.

49. Wensky. Galvanic batteries. (Price 6d.)
584. Hutin and Leblanc. Dynamo electric motors. (Price 8d.)
617. Allison (Ward). Electric arc lamps. (Price 11d.)
1,004. Thomson. Indicator for electric potentials. (Price 6d.)
1,035. Maquay. Primary batteries. (Price 8d.)
1,138. Munro. (Mino and another.) Guard for electric light globes. (Price 6d.)
2,522. Lane and Cottrell. Electric light pendants, &c. (Price 8d.)
3,198. Poudroux. Galvanic batteries. (Price 8d.)
5,043. Money and Nash. Arc lamps. (Price 11d.)
6,773. Von Orth. Signalling time, &c., by electricity. (Price 8d.)
10,259. Ginley. Railway electrical block systems. (Price 8d.)
12,322, Boult (Bassler). Electrical welding. (Price 8d.)
12,828. Lake. (Thomson-Houston International Electric Company.) Electric motors. (Price 1s. 3d).
13,553. Mitchell. Electrically-heated ovens. (Price 6d.)
16,080. Conly. Dynamo electric machines. (Price 8d.)
16,099. Bradley and others. Converting electrical energy of alternating currents. (Price 8d.)
16,456. Brookes. (Cushing.) Controlling electric circuits. (Price 11d.)
16,487. Leigh (Gardiner). Primary batteries. (Price 6d.)
16,989. Lake (Farmer). Printing telegraphs. (Price 8d.)
17,003. Madden. Secondary batteries. (Price 11d.)

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17,291. MITCHELL. Electric soldering irons. (Price 6d.)
17,406. TODMAN AND ANGOLD. Arc electric lamps. (Price 6d.)
17,430. LAMB. Electric batteries. (Price 8d.)
17,454. THRELFALL. Electric conductors. (Price 6d.)
17,652. LAKE. (Thomson-Houston International Electric Company.) Electric arc lamps. (Price 8d.)
17,971. DULANEY. (J. W. AND C. F.) Electric clock winders (Price 6d.)
17,994. SCHEITHAUER. Electric batteries. (Price 6d.)

COMPANIES' MEETINGS & REPORTS.

The Electric Construction Corporation (Limited).

The third general meeting of this Corporation was held on Tuesday at the Cannon-street Hotel, under the presidency of Mr. J. Spencer Balfour, M.P.

The SECRETARY (Mr. W. Samson) read the notice calling the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN referred with regret to the absence, through illness, of the Company's Chairman, Sir Henry C. Mance, and said that, dealing with the profit and loss account, by sales and work during the year ended September 30, 1891, the total receipts amounted to £160,000 odd, and as during the whole of the year their works had been busy, this meant over £3,000 per week of work of a manufacturing character alone. The cash and shares for licences granted, patents sold, and profits upon formation of subsidiary companies, amounted to £64,710. He wished to point out that this represented nearly all profit, and was therefore a most gratifying feature. The patents which had been sold were not, so he was informed, included in the original sales from Elwell Parker to this Corporation, and had been developments of patents which had then been floating through the mind of their extremely able engineer, Mr. Thomas Parker. Those patents had been sold or licences granted to use them, and had not in any way diminished the security they acquired when they purchased their works. These were additional profits and security acquired since that time, thanks to the genius of Mr. Parker. Out of the £64,000 they had written off no less an amount than £20,000 in diminution of capital. He thought this was an exceedingly prudent policy, and if it was persevered in for a few years to come, and their patents still remained as valuable, the result would be that their capital charges would thereby be very materially reduced, thus adding to their capacity to pay dividends. This year they proposed to write off £20,000, or, roundly, a third of the total amount received from these patents. After meeting all charges there remained a profit of £44,710. Coming to profit and loss account they would see that they had debited themselves with £3,099 for depreciation of machinery, and they had endeavoured to keep their machinery up to the highest point of efficiency. In that way they had expended over £3,000, and at the same time they had deducted £10,000 of their profit to meet depreciation of machinery; so that, as prudent men, it would be seen, that they had adopted a double course—they had put aside £10,000 to meet depreciation, and they had spent £3,000 in preventing that depreciation arising. He thought they would regard this as an exemplary policy, which might be followed with advantage by other manufacturing companies in the City of London. Their head office expenses, including rents, patent expenses, Directors' fees, managing Directors' salary, accountancy &c., stood at £11,423. At their meeting last year the amount of the office charges was challenged. He then said that so far as he was concerned part of his existence was spent in dealing with those charges, and in endeavouring to keep them down as far as possible. They would observe that those expenses during the past year had been £11,423, as against £14,000 odd during the previous twelve months—a proof, he thought, that they had been anxious to keep down the dead charges of the Company. The other expenses, including the cost of advertising, issuing debentures, law charges, &c., were £13,968. This was a considerable increase in the item over the previous year, owing to the fact that this year they had issued debentures, an operation not done without considerable outlay. They might have spread the cost over three or four years, but they preferred to bring it into the current year's accounts, and have done with it. In addition to that there were legal expenses incurred from time to time in ascertaining and maintaining the position of the Company and their patents. He could promise them every vigilance on the part of the Board to keep these expenses down; but he could not promise them, while competition was so keen on the part of their opponents, always willing to take fair and unfair advantage of the Company, that their legal charges would be very much reduced. A company like this existed by proving its capacity for fighting the rights of its shareholders with respect to the properties in which they were interested. This, of course, involved expense. He would now refer to some paragraphs in the report. The report mentioned that they had earned £46,000, after writing off £20,000 against depreciation and after spending £3,000 in preventing depreciation; and out of that £46,000 they had carried £10,000 to reserve, leaving a balance of £35,166. They then referred to their transactions during the year—some of the most interesting work which any Board could undertake—he referred to the development of the electro-chemical patents, for which they were indebted to the skill and ability and ingenuity of Mr. Parker. Their experience in this instance had been that instead of purchasing, as was often the case, for less than they had bargained for they had practically purchased a great deal more than what they bargained for. This electro-chemical business had been growing so much that they had thought it wise to place it in the hands of a separate Company; and their friend Mr. C. Ebbsmith, who had been Managing Director of this Company from the beginning, and had obtained considerable experience in dealing with the electro-chemical patents, elected to become the presiding genius of the process. He might mention as an illustration of the Company that during the last few days they had sold one of the electro-chemical patents for, in hard cash, close upon £30,000, and contingent profits of many tens of thousands more. That had been largely owing to the fact that Mr. Ebbsmith had been able to devote himself exclusively to the work. In all matters of the kind they could not have too much subdivision of labour, and the business in connection with the chemical patents was one by itself, claiming the energy and occupying the time of the ablest man they could put to it. They found that they were not holding their own with storage batteries; and their friend Mr. Courtenay, whose life had been identified with storage batteries, agreed that if they would give to his Company a licence for dealing with storage batteries, he would take up the matter as distinct from the other operations of the Company, and the result had been that the business had been sandwiched in between, and went side by side with, all the other details of that great manufacturing establishment, resulting in very large profit; since it had been placed in separate hands. He would like to express his thanks to Mr. Courtenay for the services that he had rendered and was rendering to the Corporation. The retirement of Mr. Ebbsmith, and his assumption of the position of Managing Director of this electro-chemical branch of their business, involved a considerable readjustment of the office staff; but he was pleased to say the office was now being worked most successfully, vigilantly, and economically under the direction of their friend Mr. Samson, who had been appointed secretary and chief accountant of the corporation. He wished to refer to the services of Mr. Parker. In addition to supervising the works at Wolverhampton and having to deal with a large body of men, and make them willing and anxious to help in promoting the Company, that gentleman had also taken an active part in making the patents merchantable. Moreover, Mr. Parker was consulted every day by people who had big electrical works to undertake, being recognised as the greatest living authority in respect of the manufacture of electricity. They had many items in the balance-sheet, but none representing Mr. Parker. He thought it would have been a good feature to put down a large sum as representing that gentleman. The biggest electrical work entered into in this country was the Liverpool Overhead Railway, which was being worked its entire length by electricity. That Company invited applications from the most eminent electricians in the country to supply an installation for equipping and working that railway; and in open field and with no favour the directors selected Mr. Parker's plan, and the Corporation was now carrying it out. They believed that it would be a large and profitable contract from what was really the first *bonâ fide* electrical railway started in this country. They were also, as the report stated, dealing with the question of the electric lighting of the city of Oxford. There they had accepted a contract from the Corporation to light the city, and he imagined there was no place in all England more suited for electric light installation than Oxford, by reason of the large number of colleges and other institutions perfectly ready and eager to adopt the electric light. It was, besides, a prosperous city, with a great deal of work in it. They were also supplying plant to the Crystal Palace. He supposed if there was any part of London where the electric light could be supplied with profit, it would be in the neighbourhood of the Crystal Palace. They set aside last year £15,000, and this year £10,000, making £25,000; they had written off their capital account £3,000, and for depreciation of machinery they had transferred to profit and loss account £20,000, and reduced their capital charges from £312,816 to £289,716. The only item which might be challenged, and to which he referred, was "shares in subsidiary companies at par, shares included in the original purchase at normal value, and debts due by subsidiary companies, £241,123." He had looked over the figures and he found that the companies there referred to had either paid or were about to pay a dividend, so that the shares were a good investment *per se*. But in addition to that, the fact that they held those shares was a recommendation, and enabled them to secure all the business which those companies might bring to them. With the enormous amount of competition that prevailed they must from time to time acquire an interest in large companies that had orders to give. The investments on their own merits had yielded, or were about to do so, a dividend, in addition to their having been the means of bringing large orders to the Company for which they were not bound to give competition prices, which was too often the case. He would like to read a letter which he had received from an eminent authority on electrical matters. "Another novel branch of electrical industry is the application of electricity to the electro-dissociation of metal and other substances. I am assured that it will not be long before electricity may achieve in a simple chemical manner most of the results hitherto attained by the ancient form of chemistry by the application of a costly and complex process. Already much has been done to this end. Practical men of business are satisfied that electricity is not merely a luxury, but that it has become a commercial power. The Electrical Construction Corporation are, I am sure, much indebted to Mr. Parker for his early researches and inventions in this line. The value of his patents is now undoubted. The profits which the Electrical Construction Corporation or subsidiary companies may make from the sale of patents or licences to use them is an important part of the question, but even more important must be the increased demand for the heavy class of electro-chemical machines required for the development of the power," &c. That was the opinion of a very competent gentleman on the electro-chemical patents. He ought to add that since the publication of the report they had been negotiating for a very important electrical undertaking. He had told them what they were doing in Liverpool, but in addition to that they had been approached by one of the leading tramway companies which had decided on electric traction, and had offered a contract which the Directors were now considering, for erecting the installation

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—an overhead installation—which would enable the British public to see the possibilities of electricity. He could not say whether they would accept the contract, but whether they did so or not it was one which would involve a great deal of expenditure. They were at the present moment working at high pressure. They were full of work and full of contracts. He did not think a report was ever issued which contained more hopeful statements than theirs. To have paid 6 per cent. for the first year, and to recommend it for the second; to have got their business into a more efficient state, and to have secured the necessary discipline in their very large staff, had been no light task for the Directors during the last twelve months. He concluded by moving the adoption of the report and accounts.

Sir DANIEL COOPER, Bart., seconded the motion.

Mr. HANCOCK desired to have more information as to the terms of the licence with the Electrical Storage Company, and more proof of the value of the shares of the subsidiary companies.

Dr. DRYSDALE wished to know whether it was likely that London was to ever get the benefit of electric traction. He could not understand why they had not got it, and why Liverpool should in this respect be next to New York.

Mr. OLDRITCH thought they were very much indebted to the Directors for the very able manner in which the affairs of the Corporation had been conducted, as was evinced by their ability to pay a dividend of 6 per cent., which he considered very good.

The CHAIRMAN said that the licence to the Electrical Storage Company was not given until they found that their sale of accumulators was declining, as he had told them. They found that their interests at Wolverhampton clashed with the sale of accumulators, and so they handed over the business to Mr. Courtenay. They had made every inquiry, and came to the conclusion that it was the best thing to do, and they secured for themselves with fixed charges a fixed remuneration of £9,000 a year, which was a handsome sum. With regard to the particulars as to subsidiary companies, if any gentleman went to the office Mr. Samson had instructions to afford him all reasonable information; but they were dealing with competitors, and it would be the height of folly to show their hand altogether. It was a question of confidence in the Board; if they had no confidence in them, no information that could be supplied would satisfy them. When he joined the Board he made it a consideration of his doing so, that they should not only have a trained staff, but a continuous audit. Every farthing was subject to a continuous audit by one of the best firms in the City, who examined the accounts from day to day and week to week. He quite agreed about the desirability of getting electric tramways started in London, but there were several reasons why it had not been done. The people who had been working the tramways for years did not wish to introduce a new interest, a new development; and local authorities were difficult to deal with. He did not suppose they would ever succeed in getting an overhead wire system. If they wanted to see how cheaply it could be done, it must be by that system. As to the unpaid calls, they were not losing money by these, because they charged interest on them. He believed that it would be very difficult, indeed, to find a more honestly-earned dividend.

The motion was carried unanimously.

The CHAIRMAN next proposed the declaration of a dividend at the rate of 6 per cent. per annum.

Mr. J. IRVING COURTENAY seconded the resolution, which was agreed to *nem. con.*

The CHAIRMAN proposed the re-election of the retiring Directors, Sir Henry Mance and Messrs. Ebbsmith, Holt, and Moseley.

Mr. JOHN B. VERITY seconded the motion, which was agreed to.

The CHAIRMAN next moved the re-appointment of the auditors, Messrs. Broads, Paterson, and Co.

Mr. JAMES PENDER seconded the motion, which was carried.

Mr. WILLIAMS moved the following resolution, of which he had given notice:—

"*That the Directors shall, in conformity with the power given them by Clause 128 of the Articles of Association of the Corporation, pay half-yearly an instalment on account and in anticipation of dividend.*"

"*That the Directors be requested, with a view to keep the shareholders informed of the position and prospects of the Corporation, either to hold half-yearly meetings, or, this failing, to forward to each registered proprietor in April of each year a short resumé of the Corporation operations for the previous six months.*"

Mr. HANCOCK seconded.

The CHAIRMAN said that the Directors were extremely anxious to pay an interim dividend. They had power under the Articles to do it, and they would not fail to exercise that power when they were in a position to do it; and he would, therefore, ask Mr. Williams to withdraw his resolutions. Every farthing of their money they wanted to use in the Corporation. If they could double their capital they could more than double their profits; and, inasmuch as the declaration of a dividend involved a very serious amount of investigation and examination of their plant at Wolverhampton, he would ask Mr. Williams not to press his resolutions.

Mr. WILLIAMS consented to withdraw them.

Dr. DRYSDALE then proposed a vote of thanks to the scientific staff and the Directors.

Mr. WILLIAMS seconded the motion, which was carried.

Mr. T. PARKER replied for the staff, and said that they might be assured that so long as he occupied his present position nothing would satisfy him but the complete success of the Company.

A vote of thanks having been accorded the Chairman, the proceedings terminated.

The General Electric Power and Traction Company (Limited).

The first ordinary general meeting of this Company was held on Friday last, at Winchester House, Old Broad-street; the Right Hon. the Earl of Albemarle presiding.

The SECRETARY (Mr. Thomas Smith) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN, having referred in terms of regret to the unavoidable absence of three of the Directors on account of pressing business engagements and ill-health, said: Gentlemen, this is our first meeting, and when one rises to address a first meeting it is natural that one should carry one's mind back to the time of the inception of the undertaking in which we are concerned. We began, as you know, from very small beginnings. Our numbers were very few. We did not appeal to the public. Those who have promoted this Company were not professional promoters in any sense of the word, but believers in a form of electrical application which I think we are now seeing gradually developed to the point of success. We began at Brighton with a small experimental installation; and I am bound to say that at its inception we committed as many mistakes as was to be expected under the circumstances. Every mistake was an object lesson; every mistake suggested its own remedy and its own cure; and gradually, by dint of never shirking a difficulty, never trying to evade an obstacle or get round it, but simply boldly meeting it, we found ourselves in a position three years ago to go to one of the most prominent metropolitan tramway companies, and tell them that we were able to show them that electric traction could compete commercially with horse traction, which had hitherto been the rule on their lines. We were fortunate enough, principally through the instrumentality of my friend Mr. Robert Macpherson, who is very intimate with several of the Directors of the North Metropolitan Tramways Company, we were fortunate enough to inspire them with a little of our own confidence; and the result was that we were allowed to run on a small section—two miles—of their line, which extends for 41 miles, to run a certain number of cars, under their supervision. Now, the arrangement that we made with them was that they should pay us 4½d. a mile. We were not quite sure at that time what it would cost; but we were quite certain, with the publicity which would be given to electric traction and the success which we hoped would attend our efforts, that it would be worth our while to try it. Part of the arrangement was that we should bear the cost of the initial work, and that every shilling that was spent should be expended under the direct supervision of the North Metropolitan Tramways Company, that nothing should be done without their direct cognisance, but that we should not be impeded in our operations. We did that in order that we might be able to appeal to accomplished facts. At the inception of our undertaking we were not in a position to glorify ourselves, and to say that we could do this and that; and we desired to be able to appeal to an independent company of unimpeachable character to say whether the statements we submitted to the public were justified or not. For three years we have been working on the Canning Town section of the North Metropolitan Company's tramways. From the very first we found the very greatest kindness on the part of that Company, and a great disposition to encourage us in our advances, and to help us in every way in their power, and to grant us their full confidence. I am happy to say that we have succeeded on that line very well—so well, indeed, that in the year 1889 the North Metropolitan Company found themselves in a position to apply to Parliament for permission to extend over their whole system electric traction, and entirely do away with horses. Parliament granted the request, and gave them seven years in order to form a reasonable basis on which they might raise the necessary capital and pursue their operations. We thought that everything was going on well. We satisfied the Company with whom we were contracting. We inspired them with the same confidence as ourselves; and we had obtained from Parliament, as we thought, what would extend over a large part of the metropolis the advantages of the electric system of locomotion. Unfortunately, the West Ham Corporation were of opinion that they ought to have a veto upon the construction of electric tramways throughout their district, of such a character that made it quite impossible to proceed with the work under these terms. They had no objection to the seven years, and were willing to let us have the opportunity of showing to the electric world electric traction in full operation. But I hardly know how or why they thought it necessary to insert in their Act of Parliament a provision that they should have a veto on electric traction at 24 hours' notice. Though Parliament granted seven years, they felt it necessary for their municipal purposes, if they should consider that electric traction was in any way objectionable, that they should be at liberty to give notice to the North Metropolitan Company to remove the whole of their plant within 24 hours. I need not tell you, gentlemen, that when an expenditure of £40,000 was involved, it was quite impossible for any reasonable body of individuals to undertake so onerous a responsibility as that with such a provision hanging over them at the option of a fluctuating body who might call upon them to remove their work within 24 hours. They consequently said that, satisfied as they were that electric traction was a great success, and had been proved so for two years, they must again appeal to Parliament for some modification of the terms under which they were to act. We are in this position, that this Company has renewed with the North Metropolitan Company the contract in a slightly modified form to work a piece of the Canning Town line; but until Parliament intervenes, which I hope it is going to do in the next Session, it is impossible for us to proceed further with that part of our system. We are working without accident, without hitch, and we are working at a less expense than with horses. We have proved our case up to the hilt; but, owing to the unfortunate circumstances I have detailed to you, we are unable at the present moment to proceed with that part of our district in London. That has, of course, affected

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the immediate returns which we might have expected had a more favourable result ensued. Gentlemen, I am not in the habit of using strong language, or the language of prophecy; but I am bound to say to you that that is no discouragement to your Directors and ought to be no discouragement to you. It is to a certain extent deferring your just expectation; but you will see that it is a matter beyond our control and the control of that very kind and accommodating company with which we have had relations, the North Metropolitan Tramways Company. I hope next year we shall be able to give you better accounts on that point. When a leading company, such as the North Metropolitan, had taken the matter in hand as a test case, and had to declare to the electric tramway world whether or no electric traction was a success, any delay on their part naturally influenced the general body of tramway proprietors; and it was found that we had to wait for other companies to follow their example. But from the enormous number of applications that are constantly being sent to us to introduce electric traction into various towns in the country, we think that there is a very strong feeling arising among users of tramways that electricity is the proper mode to adopt, and many proposals have been made to us to equip tramways in various parts of the Kingdom. But you will also observe that here comes in a perfectly general rule, and that is that tramway companies have usually locked up almost the whole of their available capital in their horse traction, in the cars adapted for horses, in the horses themselves and their maintenance, and in the matter of stables and all the other preparations for their system. Naturally, then, they had not a great command of money; and, though they desire to go in for electric traction, it can only be done on their own account or by making arrangements with electric companies to supply the money. While we thought that there was a future for electric traction, we also considered that we ought not to run any risk in anything which would turn into a speculation, by embarking money for the purpose of equipping tramway lines. Therefore, we have turned a deaf ear to any such proposal, and I hope you will approve the prudence which the Directors have shown with regard to that. It is just as in the case of the delay with respect to the North Metropolitan Company; it has somewhat postponed our ultimate success, but it will make it more sure. It has demonstrated that success will come. I will turn now to another part of our business which has been very largely developed, and which has been successful to a degree which has afforded great satisfaction to the Directors—I mean working in mines and coal winning which is more recent than pumping. Electric pumping in mines has been developed to a very considerable extent, and has employed our works in a very satisfactory manner, and with fair returns. But that, like the whole of the electric industry, is still in its infancy, and we hope to see it very largely developed. But we have very great confidence in it. I believe we have a very considerable percentage of all the electric hauling that is done in mines in our hands—75 per cent., I believe; but I won't pledge myself to that, preferring to leave that to experts—but I think we have a very fair proportion of such work as is done in mines by electricity; and from indications that are constantly coming before us, we may say that the mining interests are coming more and more to believe in the feasibility and the economical qualities of electricity, that we shall have an extension in that direction. There is another point to which we have considerably devoted our attention—that is, electric boats. Now, with respect to them, I must say that we stand alone. We have got a large fleet of boats already on the Thames, started by Mr. Immisch and continued and developed by his successors, this Company. It is daily increasing. We find that foreign Governments are coming to us for electric propulsion to be applied to boats. We have hopes that the English Government will come to us, but it is not so quick in its movements as some other Governments are. At any rate, we are acquiring a very considerable amount of confidence among the users of electric launches. We have gone into the question of the electro deposition of copper and we find there a larger possibility. I must say that all that I have been able to learn, and all that my colleagues have been able to learn, on this point, that in entering into that industry we are embarking on something which ought to give very good results. As I said, I never like to indulge in the language of prophecy; but I must confess to entertaining considerable confidence in my own mind, and I think I speak for my colleagues as well—of the success of that branch of business. Then there is the general question, we are purveyors of electric plant. They say that a prophet has no honour in his own country; but lately the St. Pancras people round our own works have got an electric installation for lighting their district, and I am happy to say that the confidence which has been shown by the people in that district in their immediate neighbours, the works of this Company has been very great, and we have been called upon to supply the electric fittings for the installations in the St. Pancras district. I think that is an encouraging thing, because it shows the feeling which exists among our immediate neighbours, and their capability of appreciating our work. I do not think that I need detain you longer, but my friend the general manager reminds me that we have sent out general estimates amounting to £400,000, of which £150,000 in orders have been promised next year. There are places where the Corporations themselves have taken into their consideration the advisability of adopting electric traction for the municipal tramways; and in those cases the difficulties I have described in the case of the West Ham Corporation, and in the case of tramways generally, will not occur, and I am happy to say that we are in intimate connection and negotiation with some very large Corporations who are proposing to alter their mode of traction to electricity. Though it would not become me to speak with any positiveness about anything which is not actually concluded, the shareholders will at once see that it is necessary prudence on my part. I hope that next year I shall be able to give you a very good account of that part of our business. Subject to any questions which may be asked by the shareholders, I will conclude by moving:—

"*That the report and accounts be adopted, and that the agreed dividend of 7 per cent. on the preference shares be hereby declared, and that the same be payable on January 22, 1892*"

Mr. THOMAS FULLER seconded the motion, which was agreed to without discussion.

Mr. TURNER moved:—

"*That Messrs. Ward and Wilding be re-elected auditors to the Company, the remuneration being fixed at fifty (50) guineas.*"

Mr. C. KING SMITH seconded the motion, which was also carried.

Mr. EBB-SMITH proposed a vote of thanks to the Chairman and Directors, which

The CHAIRMAN briefly acknowledged; and the proceedings terminated.

Fowler-Waring Cables Company (Limited).

The third ordinary general meeting of this Company was held on Thursday, December 17th, at Winchester House, Old Broad-street, Mr. William Fowler presiding.

The SECRETARY (Mr. D. Stephen) having read the notice calling the meeting,

The CHAIRMAN said: I have now to move:

"*That the report and accounts, as delivered, be received and adopted.*"

In doing so I wish to say, in the first place, that I am very sorry that Mr. Chamberlain, one of our most active and useful Directors, is ill, or he would have been present with us. He writes me to say that he wishes me to express his great regret at his absence, and his entire confidence in the future of the Company. I have also a letter of the same tenor from Mr. Gathorne-Hardy, who is unavoidably detained in the country. Now, gentlemen, our report is so full as regards the actual condition of the Company, combined with the report of the Manager, that it is not necessary for me to detain you at any length. We have expressed regret—and I feel very much regret—that we have not been able to declare a dividend this year, but I can hardly say that I am greatly surprised, because it is just one of those businesses which take some time to develop, and therefore we cannot expect to obtain a dividend exactly as we should in many other kinds of business. I wish also to say especially that all business of this kind—every business, in fact, but this kind of business especially—depends on management. Now, when I was here a year ago almost exactly, I expressed my confidence in the management as it had then just been settled. Our present manager had, I think, been five months in office when we met last year; and I wish again to express my still greater confidence in him, and my sense of the energy and ability which he has shown in the management of the affairs of the Company. And I think that those who know him outside the Company will not be surprised at my making that statement. Now, what you will say is: "That is all very well, but we want to know what you think about the prospects of the Company?" Well, gentlemen, I expressed myself with satisfaction last year at the belief and hope that our prospects were good. What I said has been fully borne out. We have had a great increase in the business of the Company, and we see before us immediately, I think, a still further increase: and I have really great hopes—I think I may say an expectation—that if we are all alive and well next year we shall have something very satisfactory to report, and not merely something to report, but something to divide, which is a great deal more satisfactory than anything that might be reported. We have large additional orders coming in at the present time, and the inquiries are numerous and important. I am very careful when I occupy this position not to overstate things or to hold out expectations which are not likely to be realised; but I feel confident that this Company, notwithstanding all the difficulties that it has to meet, in great competition and the continual changes that take place, owing to inventions in electrical affairs—I feel confident that, notwithstanding all these peculiar difficulties, we shall have, with the kind of management we have now, a prosperous year; and not only a prosperous year, but, I hope, many prosperous years. I do not think that I need detain you with any more details. The accounts speak for themselves. We have explained everything on the face of the accounts, and any shareholder who has studied them can understand them. Still, if any question occurs to you to ask I shall only be too happy to hear it. I repeat my great regret that we have not something to give you this time, but I say again that I feel great confidence in the future of the Company. I now beg to move that the report and accounts be received and adopted.

Mr. GEORGE FLEMING: I second that.

The CHAIRMAN: If any gentleman has any question to ask, I shall be happy now to hear him. No shareholder rising, he put the motion in the usual way, and declared it carried unanimously. Continuing, he proposed the re-election of Mr. Walter Chamberlain and Mr. R. W. Eddison to their seats at the Board.

Mr. R. S. WARING seconded the motion, which was carried unanimously; and Messrs. Cooper Brothers and Co. were afterwards re-appointed auditors to the Company.

The CHAIRMAN: I should just like to add that Mr. Eddison has lately been to America, and has spent a great deal of time there—and I think usefully—in the interests of the Company in finding out what is going on, and obtaining information which will be of great value to us. I believe that is the whole of the business of the meeting.

The proceedings then terminated.

British Tanning Company.

The annual general meeting of the shareholders of the British Tanning Company (Limited) was held at Winchester House on Friday last; Mr. Adolphus Horny presiding.

Mr. H. HODGES (the Secretary) having read the notice convening the meeting,

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The CHAIRMAN said he should like to go a little into the accounts, and to compare some of the figures with those of last year. The stocks in hand in 1891 amounted to £1,157, against £2,262 the year before, showing a diminution of £1,105. The purchases of raw materials were this year £2,365, against £5,662 in the previous year, or £2,297 less than before. The sales of manufactured goods amounted to £3,431, against £1,804 last year, showing an increase of £1,627 during the year. Salaries, wages, and office expenses, which came to £1,002, represented a reduction of £700. The law expenses had been £1,086, as against £424 the year before, or an increase of £662. He would go into this item more fully presently, because it was one of the principal items in the account. They had written off 25 per cent. for depreciation of plant. In the first year they did not write off anything on that account. The share capital was practically the same as last year. The amount of £20,000 which was down as having been paid to vendors under agreement had not been paid in cash. The greater part had been paid in shares, and only a small portion in cash, which showed that the inventors had great confidence in the Company. The balance to profit and loss account was £3,809, as against £5,230 the year before, or a reduction of £1,421; and when an allowance had been made for the heavy law expenses of the year, it would be seen that there was a great improvement as compared with the previous year. He would now give the meeting a short sketch of the experience of the Company during the year. He was glad to say they had got out of the lawsuit about which they were informed when they met the Directors in December, 1890. As they were aware, the Directors had to vindicate their rights to their patent against a person who had taken out another patent, which, according to the best opinion, was only a slight modification of the patent of this Company. Counsel informed the Directors clearly that that patent was an infringement of their patent, and they were then told by their legal advisers that it was their bounden duty to put a stop to the working of the other patent by commencing a lawsuit. They did so, and the case came before Mr. Justice Romer in January last; but he was sorry to say that it was decided against them, on the ground that the difference between the working of the two patents was sufficient to constitute a new patent for the other process. It was further stated that the Company's own patent was invalid by reason of a prior publication. They then thought that for a time they really had no patent at all, and they had to decide what was best to be done under the circumstances. First they sought to make the vendors in Paris responsible for the loss the Company had sustained, and claimed a return of the amount they had received from the Company, with damages. However, the vendors objected to this course, on the ground that the lawsuit had only been decided in the first Court in England, and the result might not be confirmed in a Court above. The Directors were about to appeal to have this decision reversed, but the Attorney-General advised them that there was not the slightest chance of their succeeding. So, finally, on the advice of their legal advisers, application was made for a special Act of Parliament, which had for its object the reviving of the Company's patent. The Worms and Bale Patent Bill was accordingly introduced into the House of Lords in April, and, despite all opposition, passed both Chambers, and received the Royal Assent on July 28, 1891. Their property had thus been restored to them—a result chiefly due to the exertions of their solicitors. That brought him to a consideration of the position of the Company at the present time. As they all knew, it was very expensive to go to law, and also to get a private Bill passed through Parliament. Therefore there had been a great strain on the resources of the Company, and their manufacturing work could not be carried on upon such a scale as would otherwise have been the case, so as to obtain a profit by it. At the same time they would make the inventors in Paris responsible for a great part of the legal expenses, and they had also reasonable hopes that the money they so claimed would soon come in. In the meantime they had taken process in Paris, which would prevent money going to the inventors from other foreign patents they might sell until the claim of this Company had been settled. The shareholders would now like to know, perhaps, that three such patents had been sold to Brazil, Uruguay, and the Argentine Republic for £50,000. This would prove to the tanning industry in England that other countries appreciated the process adopted by this Company, and should make them regard it with more favour than they had hitherto done. It would thus be seen that they had a valuable patent, that they were in a far stronger position than they were before, and that they had made, and could make good leather in a very short time, as stated in the prospectus. If, however, they were to continue to manufacture it would be necessary to have funds which would enable them to do it on such a scale as they could make a profit out of it. To this end they had entered into negotiations with various parties both at home and on the Continent, and they hoped to be able to obtain the assistance they required. But for the present they did not want any further capital, and they would not decide anything without calling the shareholders together and obtaining their authority. They would all be sure that the Directors would not ask for further funds until they were confident that the prospects of the Company warranted the adoption of such a course. He would now inform them that they had entered into negotiations with a firm of first-rate tanners to take over the whole of the Company's plant, work it with their own capital, make their own purchases and sales, and prove in that way that the Company's process could be worked under ordinary conditions with a profit in the same way in this country as in others. He believed that such an arrangement was likely to be carried into effect. In conclusion, the Chairman said he could not see why they should not prosper and have as good results as were obtained in Paris and elsewhere. He then moved the adoption of the report and balance sheet.

Mr. DUFRESNE seconded. He could not see why a process which had been proved to have been a complete success elsewhere should not also be as great a success in England. It was in consequence of the experiments which had been made that the South American patents had been sold. The difficulty with which this Company had to contend was vested interests, but he had little doubt as to its ultimate triumph.

Mr. RIDLE, a shareholder, asked for some further information relative to the solicitors costs.

The CHAIRMAN said the solicitor's bill for law expenses to June 30th, including those of the lawsuit, amounted to £1,305, of which £250 had been paid. £652 10s. would have to be paid by the Paris inventors, quite irrespective of the expenses of obtaining the private Bill in Parliament, which amounted to £690. Altogether, therefore, the vendors owed the Company in respect of these matters £1,342.

The report and balance-sheet were then adopted, after which the auditors, Messrs. Cooper Brothers and Co., were re-elected.

A vote of thanks to the Chairman and the Board of Directors closed the proceedings.

The Gulcher (New) Electric Light and Power Company (Limited).

The fourth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on Friday last; Mr. R. Pryor presiding.

The SECRETARY (Mr. T. C. Morgan) read the notice calling the meeting and the minutes of the previous meeting, these latter being confirmed and signed.

The CHAIRMAN explained that the meeting had been called to comply with the statute, and they desired it to be adjourned for two months, by which time the Chairman of the Company, now on his way back from New Zealand, would have arrived and be able to furnish them with the results of his visit. He accordingly concluded by proposing a motion to that effect.

Mr. H. GRÈWING seconded the motion, and it was agreed to.

Elmore's Patent Copper Depositing Company (Limited).

The following is the second annual report of the Directors of this Company to the 30th June, 1891, to be presented to the shareholders at the Cannon-street Hotel, on Wednesday the 30th December inst., at 12 o'clock:—

The Directors have pleasure in submitting to the shareholders their report, and in congratulating them on the satisfactory technical and commercial prospects of the Company. The accounts show a credit balance at the end of the preceding year of £77,825. 1s. 4d., from which two dividends of 10s. each, making £1 on each £2 share, were paid. It will be seen from the accounts, which accompany the report, that there were credit balances on June 30th last of £14,261. 17s. 10d., made up of £5,000 royalties on copper sheets received in advance, £8,558. 7s. premiums and profit on land, and balance of profit and loss of £703. 10s. 10d., a satisfactory result considering that the Company had only been able to manufacture small quantities of articles at the date of making up of the accounts—work on a large commercial scale not having been then commenced.

The Directors have much satisfaction in announcing the successful completion of the 20-ton plant, and thus the programme of work set forth in the prospectus has been carried out. The cost of manufacture has also now been found to be only about ½d. per pound weight of finished goods, that is to say, about one-half the cost that the Directors estimated in the prospectus, whilst the statements as to the technical features of the process have been entirely proved. The Directors are the more gratified in being able to refer to these results, as, though the application of the essential part of the Messrs. Elmore's invention has remained unchanged, various difficulties connected with the mechanical details of the process, inseparable from the commercial development of all important inventions, were encountered. These caused some considerable delay.

The Managing Director reports that all these difficulties have now not only been successfully overcome, but that they have led to the taking out of additional patents of great value, which will have the important practical effect of prolonging the monopoly of the invention. Foremost amongst these may be mentioned the patent for the manufacture of sheet copper, the licence to work which on a royalty, which will prove a valuable source of income to this Company, has been granted to Elmore's Wire Manufacturing Company.

The Directors desire specially to draw the attention of the shareholders to the purchase of the Haigh Park Estate, Leeds, consisting of 127 acres of freehold land, on a portion of which site the Company's works have been erected. The purchase of this property was rendered advisable by the impossibility of acquiring portions of it required for the purposes of the Company and its future extensions, except at the price of £2,000 per acre, whereas the price actually paid for the whole estate was only £534 per acre, including all expenses. The land is within half a mile of the Borough of Leeds, connected by sidings with the Midland and Great Northern Railways, and has a wharf on the Aire and Calder Canal, which latter bounds the estate for three-quarters of a mile. It has an extensive frontage to the Pontefract high road, and is in close proximity to cheap coal supplies. The new line of the South Leeds Junction Railway, for which a Bill has been lodged in Parliament, is planned to run through the estate. These advantages and improvements have resulted in what the Directors foresaw, viz., a great increase in the value of the land, which must make the purchase a valuable acquisition for the Company. Negotiations have already taken place for the sale of portions at a considerably higher

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price than that paid. A plot of 13 acres has been disposed of at £1,000 per acre to Elmore's Wire Company; and this price, whilst yielding an excellent profit to your Company, is nevertheless 50 per cent. below the price demanded for this plot by the former owner, and the Directors are advised that they will be enabled to dispose of the whole of the land not required for the purposes of the Company at a similar profit.

The completion of the 20-ton plant was lately marked by an invitation to the larger shareholders to see it at work, and over 100, from various parts of the country, availed themselves of this invitation, and they expressed the greatest satisfaction at what they saw.

The Messrs. Elmore have made a joint report to the Board as to the earning-powers of the works. This report is of a most important character and is enclosed herewith. By this report it will be seen that the profits of the works as now completed are put at over £45,000 per annum, being 30 per cent. upon the present capital of the Company, whilst when the time comes for doubling the output to 40 tons per week the profits will be increased to over £95,000 per annum, equal to nearly 50 per cent. upon the increased capital that will then be required. These returns, extraordinary as they may seem, Mr. Elmore fully believes will be exceeded by actual results; and considering that the report takes no account of important sources of profit such as sales of licences, recovery of precious metals, and special kinds of work, the Directors see no reason to doubt the conclusions therein contained.

From the numerous testimonials from important firms, copies of some of which have already been despatched to the shareholders, it has been shown that the goods supplied to customers have given complete satisfaction, and of this the numerous repeat orders, and the offers of a very large additional business at remunerative prices, are a still better and more practical proof.

The Directors desire, in conclusion, to record their belief that, now that the Company may be considered to have entered upon its legitimate manufacturing business on a commercial scale, the shareholders will find that in the Elmore invention they possess a process that will be a continual source of profit, increasing from year to year, as the quality of the goods produced becomes more and more known.

The Directors who retire are Sir John Morris, Mr. Atkinson, and Mr. Carson; the former, owing to continued ill-health, does not seek re-election; the latter two are eligible, and offer themselves for re-election. The auditors, Messrs. Price, Waterhouse and Co., also retire and offer themselves for re-election.

A report by the Messrs. Elmore accompanies the Directors' report and accounts, from which we learn that the Messrs. Elmore confidently anticipate the eventual earnings of the Company to return *over 50 per cent. per annum*. The following also accompanies the copy of the report we have received:— "Since the Directors' report was made out, the result has been received from Leeds of an important competitive trial that has just taken place of an Elmore tube, nine inches in diameter and one-eighth of an inch thick, against the best brazed tube obtainable of similar size made by the ordinary system. The tests showed that the brazed tube burst in an uneven manner at 448 lbs. pressure. The Elmore tube stood at 1,456 lbs. pressure, being over three times as strong, and then gave way gradually and evenly. Some idea may be formed of the strength of the Elmore tube when it is mentioned that the testing machinery had to be specially prepared, owing to the enormous resisting power of the Elmore tubes."

Elmore's Wire Manufacturing Company (Limited).

The following is the first annual report of the Directors of this Company, and is for the period from March 15, 1890, to October 31, 1891; to be presented to the shareholders at the Cannon-street Hotel, E.C., on Wednesday, the 30th inst., at three o'clock.

The period with which this report deals has been devoted entirely to the erection of the Company's works upon thirteen acres of freehold land purchased from the Parent Company and immediately adjoining that Company's works. The main building consists of a series of bays, each 400ft. long by 35ft. wide, having a total width of 350ft. under one roof, and covering a space of about 3½ acres. These buildings have been designed with a view to an output of 140 tons per week. There are also offices for the staff and Managing Director complete in every respect, together with convenient store and packing shed, with sidings from the Midland and Great Northern Railways already connected up therewith. [The actual progress made at the works is here set out in the report.]

It will be seen (the report proceeds) that the works will make a start with an output of about 35 tons a week. This can be readily increased up to 70 tons a week with little additional expenditure above that already incurred.

The Company has also acquired from the Parent Company, upon a moderate royalty, the sole licence outside the requirements of the Parent Company, for the manufacture of copper sheet, under a patent taken out by the Parent Company last year; and the Board consider, in view of the large demand for copper sheet, that this licence will prove of great value.

Since the Company was formed, and the buildings commenced, the Directors have learned with satisfaction that the whole of the proposed output can be readily disposed of in the form of ribbon or tape, and planished sheet, at a profit considerably in excess of that estimated from the sale of wire spirals. The Company will therefore neither erect wire-drawing plant on a large scale for the present, nor dispose of its copper spirals to wire-drawers, thus adding to the gross earnings of the Company one manufacturing profit.

Mr. Elmore, Managing Director, reports that early in the year 1892 the Company will be in a position to commence with an output of 35 tons per week.

In regard to the accounts, which accompany the report, these are exceedingly simple; inasmuch as no trading account having yet been opened, the only outgoings beyond capital expenditure are those occurring under administration expenses, which, however, have been reduced by one-half, largely in consequence of the satisfactory profit derived from a judicious investment last year in Consols and Bank of England Stock.

The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., offer themselves for re-election, and the Directors recommend a payment to them of 35 guineas for their services.

NEW COMPANIES, STATUTORY RETURNS, &c.

BEDFORD AND KEMPSTON TRAMWAY COMPANY (LIMITED).—This Company was registered on December 17, 1891, with a capital of £10,000, in £10 shares, by Barnard and Taylor, 47, Lincoln's Inn-fields, London. The objects are to construct, purchase, lease, or otherwise acquire any tramway or tramways in the parish of St. Paul and St. Mary, in the Borough of Bedford, and in the parish of Kempston, in the county of Bedford, and to equip, maintain, and work by animal, steam, electrical or other mechanical power all tramways belonging to the Company.

FIRE EXTINGUISHING COMPANY OF INDIA (LIMITED).—This Company was registered on December 14, 1891, with a capital of £2,500, in £1 shares, by Busk and Co., 45, Lincoln's Inn-fields, W.C. The Company has for its objects the purchase and acquisition of certain patents, patent rights and inventions for, or in connection with an electric fire indicator and suppressor, and to work and develop the same.

JOHN WILKES, SONS, AND MAPPLEBECK (LIMITED).—This Company was registered on December 14, 1891, with a capital of £250,000, in £5 shares, by Waterlow, Brothers and Layton (Limited), Birchin-lane, London, E.C. The objects are to purchase or otherwise acquire as going concerns the businesses of copper smelters, refiners, manufacturers of brass and copper sheets, tubes, wires, and rolled metal, heretofore carried on in Liverpool-street and Abberley-street, both in the City of Birmingham, under the respective styles of "John Wilkes and Sons," and "John Wilkes, Mapplebeck and Co.," and to carry on the business of copper smelters and refiners, brass founders, metal workers, iron and steel converters, mechanical engineers, &c. Registered office: Liverpool-street, Birmingham.

SOMERTON, KEINTON-MANDEVILLE, CASTLE CARY, AND EVERCREECH TRAMWAYS SYNDICATE (LIMITED).—This Company was registered on December 14, 1891, with a capital of £1,500, in £50 shares, by Hargreaves and Co., 9, Bridge-street, Westminster, S.W. The objects are to acquire and take over the consents obtained by the Local and Road Authorities to the construction and maintenance of a tramway, and the use of steam, electrical and other mechanical power thereon, from Evercreech to Castle Cary, thence to Keinton-Mandeville, and thence to Somerton, and to equip and work the said tramway. Registered without Articles of Association.

BLACKPOOL ELECTRIC TRAMWAY COMPANY (LIMITED).—The annual return of the above-named Company, made up to December 12th, 1891, was filed on the 17th following. This Company was registered on January 24th, 1884, with a capital of £30,000 in £10 shares, to work what was called Holroyd-Smith's Patent. At the time of making-up, the whole of the shares had been taken up, 150 of which had been issued as fully paid. Upon the remaining 2,850 £6 10s. per share had been called, resulting in a payment of £18,525. Registered office: Albert-terrace, opposite Bailey's Hotel, Blackpool.

CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).—An agreement was made on November 7, 1889 (and filed on December 15, 1891) between the above Company (referred to as the Chelsea Company) of the one part, and the Callender's Bitumen Telegraph and Waterproof Company (Limited) (referred to as the contracting Company) of the other part, which states that, whereas the contracting Company has agreed to supply certain goods, and to do certain work in the event of its being required to the Chelsea Company, it is therefore agreed that the contracting Company shall, upon receipt of a notice in writing within six calendar months from this date, supply, deliver, and fix in working order, at such places in Chelsea or Kensington as the Chelsea Company may direct, the plant described in a specification signed by two Directors and the secretary of each Company. In consideration of the supply, delivery, and fixing of the said plant, the Chelsea Company shall pay to the contracting Company £1,520, one-third of which shall be paid in cash, and two-thirds in fully paid-up shares or in cash at the option of the Chelsea Company, and the contracting Company agrees to accept the said shares and cash in full payment for the said work and plant. By an agreement made December 15, 1891 (and filed on the same day) between the same parties, the work mentioned above having been completed to the satisfaction of the Committee of consulting engineers of the Chelsea Company, who have signed a certificate, dated December 7, 1891, to that effect, the contracting Company agree to accept the allotment of 304 fully paid-up ordinary £5 shares in the Chelsea Company, numbered 7,908 to 8,211, both inclusive, in full satisfaction for the supply of the said plant and the work done. The above named Company was registered on November 18, 1884, with a capital of £100,500, divided into 20,000 ordinary shares of £5 each, and 500 founders' shares of £1 each. The Directors in 1888 were the Right Hon. Lord Thurlow, J. I. Courtenay, Esq.; Nugent Daniell, Esq., Sir George R. Prescott, Bart., and Major-General C. E. Webber, C.B. Present registered office: Draycott-place, Chelsea, S.W.

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GLOBE ELECTRIC COMPANY (LIMITED).—The following was filed on December 14, 1891:—An agreement made November 30, 1891, between Sir William Vavasour, of Hazlewood, Yorkshire (called the vendor), of the one part, and the above-named Company of the other part, states that whereas, by an agreement dated November 30, 1891, between the same parties, the Globe Company agreed, in consideration of the assignment of certain patents, to issue to the vendor 5,500 fully paid up shares of £1 each, it is agreed that the Company shall, before December 1, 1891, allot to the vendor or his nominees the 5,500 fully-paid up £1 shares in the purchasing Company. The above-named Company was registered on November 4, 1891, with a capital of £10,000, in £1 shares. Registered office: 36, Great James-street, Bedford-row, London, W.C.

GORDON ELECTRIC TRACTION SYNDICATE (LIMITED).—The annual return of this Company, made up to December 9, 1891, was filed on the 17th following. The Company was registered on August 13, 1890, with a capital of £2,400 in £10 shares, to purchase the invention of John Gordon of a system of electrical car traction, and the provisional protection for the same, dated May 5, 1890, and numbered 6,083, and to work and develop the same. At the time of making up, 206 shares were taken up, of which 60 were issued as fully-paid. On 133 of the remainder, £10 per share had been called, and on 13 £5 per share, resulting in a payment of £1,395. Registered offices: the offices of Messrs. Merryweather and Sons, Greenwich-road, Greenwich, Kent.

NATIONAL TELEGRAPH WORKS COMPANY (LIMITED).—By an agreement dated December 7, 1891 (and filed on the 12th), between J. Slater Lewis, telegraph engineer, of the one part, and the Company of the other part, the vendor agrees to sell and the Company to purchase the interest in an invention of an improved method of manufacturing window sashes or frames; and also the business of manufacturing electric, telegraph, telephone, and railway instrument batteries, and other electric appliances as carried on at the National Telegraph Works, 109, Wainwright-street, Aston, near Birmingham. The purchase price to be paid to the vendor for his said invention and the goodwill of the said business shall be 35 fully paid-up founders' shares of £1 each. For the other property agreed to be sold, viz., the net balance of assets over liabilities, to be ascertained by the auditors of the Company, the vendor shall accept fully paid-up ordinary shares. The vendor, so long as he is able and holds at least 150 fully paid-up shares, shall be managing Director for five years from August 24, 1891, with a salary of £250 per annum, and an additional £50 per annum for each 2½ per cent. up to 7½ per cent. paid as dividend. A supplementary agreement to the above, made December 11, 1891 (and also filed on the 12th) between the same parties, states that whereas Messrs. Rhodes and Co., chartered accountants, of 34, Waterloo-street, Birmingham, have ascertained the net balance of assets over liabilities, due to the vendor, as the purchase price for the property to be £525, it is therefore agreed that the total amount due and to be paid to the vendor is as follows:—(1) The purchase price for the invention and goodwill of the business, 35 fully paid-up founders' shares, numbered 1 to 35 inclusive, to be allotted to the vendor; (2) purchase price for the other property agreed to be sold at the net balance of £525, ascertained as aforesaid, to be satisfied by the allotment of 105 fully-paid ordinary shares of £5 each to the vendor; and (3) the debit balances found to be due from the vendor in respect of the said invention, business, plant, machinery, articles, and things mentioned in the principal agreement, £1,799. 10s. 6d., the total purchase consideration being £2,359. 10s. 6d. Registered office: 109, Wainwright-street, Aston, near Birmingham

NEW TELEPHONE COMPANY (LIMITED).—The following notices were filed on December 14, 1891:—At an extraordinary general meeting of the members of the above-named Company, duly convened and held at 90, Cannon-street, in the City of London on November 6, 1891, the following special resolutions were duly passed, and at a subsequent extraordinary general meeting of the members of the said Company, also duly convened and held at the same place on November 25, 1891, the following special resolutions were duly confirmed:—(1) That the existing shares in the capital of the Company be consolidated into 12,000 shares of £10 each. (2) That the capital of the Company be increased from £120,000 to £750,000, by the creation of 62,700 shares of £10 each, and 3,000 new shares of £1 each. (3) That the new regulations submitted to this meeting and intituled "Articles of Association of the New Telephone Company (Limited)," be and are hereby adopted as the regulations of the Company, to the exclusion of, and in substitution for, all the existing regulations of the Company. The new Articles of Association, which were filed with the above notice, states that the capital of the Company is £750,000, divided into 74,700 ordinary shares of £10 each, and 3,000 founders' shares of £1 each. The founders' shares are to be offered for subscription to his Grace the Duke of Marlborough, Mr. R. W. Wallace, and Mr. Charles Davis, three of the Directors of the Company, through whose intervention, and at whose instance, the winding-up of the Company was stayed in 1891, and the Company was enabled to resume business. The number of Directors is not to be less than three nor more than nine, the first being the above-named gentlemen. Qualification, £500. Remuneration, £3,500 per annum, to be divided as they themselves determine. The above-named Company was registered on November 20, 1884, with a capital of £120,000, in £5 shares, to acquire several letters patent for Great Britain for inventions for improvements in electrical apparatus for the transmission and reproduction of sound, granted to Silvanus P. Thompson, or to S. P. Thompson and Philip Jolin jointly, and the first Directors were the Right Hon. Lord Thurlow, the Right Hon. Lord Sudeley, Sir Daniel Cooper, Bart., and John Irving Courtenay, Esq. By an agreement dated May 6, 1885, between the vendors and the Company, S. P. Thompson had 1,000 £5 fully paid-up shares allotted to him in full satisfaction of his proportion of the first issue of shares. At an extraordinary general meeting of the members of the Company, held at 4, Great Winchester-street, E.C., on April 27, 1889, Sir Daniel Cooper in the chair, the following resolution was passed: "That it has been proved to the satisfaction of the meeting that the Company cannot, by reason of its liabilities, continue its business, and that it is advisable to wind up the same, and accordingly that the Company be wound up voluntarily;" and at the same meeting Mr. W. S. Ogle, of 90, Cannon-street, E.C., was appointed liquidator for the purposes of such winding-up. In the High Court of Justice (Chancery Division), on June 1, 1889, it was ordered by Mr. Justice Stirling that the voluntary winding-up of the Company be continued subject to the supervision of the Court. But on July 10, 1891, in the High Court of Justice (Chancery Division), upon the petition of Prof. Silvanus P. Thompson and Emile Garcke, Esq. (of the Brush Electrical Engineering Company, Limited), Mr. Justice North ordered that all further proceedings in relation to the winding-up of the Company be stayed. The last return, made up to January 3, 1891 (filed on September 17, 1891), shows that while the nominal capital was £120,000, in £5 shares, 3,000 shares had been taken up, of which 1,000 had been issued as paid. £5 per share had been called upon the remainder, resulting in the payment of £9,960, while £40 was in arrears. Present registered office: 90, Cannon-street, London, E.C. The official notice, informing the Registrar of Joint-Stock Companies, in accordance with the Companies' Act, 1862, that the existing 24,000 shares of £5 each in the capital of this Company have been consolidated into 12,000 ordinary shares of £10 each, was filed on December 15, 1891.

SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to December 8, 1891, and filed on the 17th following, shows that out of a capital of £1,000,000, in £5 shares, 78,949 ordinary, and 19,750 fully-paid shares have been taken up. Upon the ordinary shares £3. 10s. per share has been called, resulting in a payment of £279,851. 10s. £98,750 is considered as paid, and £3,530 is the total amount paid on 1,201 shares, which have been forfeited. The following are the holders of 500 shares and upwards:—C. Gill, Java Lodge, Beckenham, 500; E. W. Batt, 15, Great Winchester-street, E.C., 550; W. Agnew, M.P., Summer Hill, Pendleton, Manchester, 1,000; T. S. Allpress, 55, Victoria-street, S.W., 550; G. J. Fenwick, banker, Newcastle, 1,000; executors of A. Field, 700; A. S. Stevenson, Tynemouth, 700; Right Hon. W. H. Smith, M.P., 3, Grosvenor place, S.W., 500; A. Morrison, 53, Coleman-street, E.C., 2,000; J. Dilks, Nottingham, 500; London Trust Company, Limited, 500; F. R. Leyland, 49, Prince's Gate, S.W., 3,319; H. S. Cole, Blenheim Lodge, Sutton, S.W. 1956; S. E. Phillips, Shooter's Hill, 800; J. Balfour, 14, King's Arms Yard, E.C., 2,502; R. Paull, 1,100, and D. Mackinnon, 1,250, 13, Austin Friars, E.C.; W. C. Quilter, M.P., 14, King's Arms Yard, E.C., 5,044; H. C. Donovan, Middleton House, Westcombe Park, S.E., 670; H. L. Bischoffshein, 31, Throgmorton-street, E.C., 550; G. M. Davey, 20, Essex-street, W.C., 550; C. Morrison, 53, Coleman-street, E.C., 758; Viscount de Stern, 10, Great Stanhope-street, W., 2,500; B. Pell 6, Granville Park, Blackheath 1,000. The principal holders of the fully-paid shares are S. White, Temple-street, Liverpool, 6,900; J. W. Swan, Lauriston, Bromley, Kent, 2,625; S. White and J. C. Swan, of 1, Dean-street, Newcastle, 1,400; and F. R. Leyland, 1,725.

THETFORD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The first return of this Company, made up to November 30, 1891, was filed on December 14, 1891. The Company was registered on June 23, 1890, with a nominal capital of £5,000 in £10 shares. 368 shares have been taken up, upon each of which £6 has been called and paid, with the exception of £3. The principal shareholders are Mr. W. Jackson, of Knottingley, Yorks, and Messrs. Charles Burrell and Sons (Limited), of Thetford, Norfolk, each of whom hold 175 shares. Registered office: St. Nicholas-street, Thetford, Norfolk.

WOODHOUSE AND RAWSON UNITED (LIMITED).—The annual return of this Company, made up to November 27, 1891, was filed on the 17th of the following month. The Company was registered on July 12, 1889, with a capital of £350,000, in £5 shares, to unite the businesses of (1) Woodhouse and Rawson (Limited), (2) Woodhouse and Rawson Electric Supply Company of Great Britain (Limited), (3) Woodhouse and Rawson Electric Manufacturing Company (Limited), (4) Woodhouse and Rawson Electric Contract and Maintenance Company (Limited), and (5) C. L. Baker and Company (Limited). On the 12th February last the capital was increased to £350,000, making 60,000 ordinary and 50,000 preference shares of £5 each. Of these, 55,170 ordinary and 41,118 preference shares have been taken up, of which 8,564 ordinary and 9,936 preference shares (a total of 18,500) were issued as fully paid. On 34,107 shares £5 per share has been called; on 5,281, £1 per share; on 4,045, £2 per share; and on 34,355. £2 10s. per share has been called, resulting in a payment of £268,163 10s. (including calls in advance), leaving £1,630 in arrears. £92,500 is considered as fully paid, and £11 10s. has been paid on 3 ordinary and 20 preference shares which have been forfeited. Registered office: 88, Queen Victoria-street, E.C.

CITY NOTES, &c.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED). — Notice is given in our advertisement columns that the coupons on this Company's Four per Cent. Mortgage Debentures to bearer, due January 1st next, will be paid on and after that date, at the Alliance Bank, Bartholomew-lane, London, E.C. Coupons must be left at the Alliance Bank three clear days for examination.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED). — Our advertisement columns contain a notice that the coupons on this Com-

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pany's Second Issue of Five per Cent. Debentures, due 31st inst., will be paid on and after that date at the Alliance Bank, Bartholomew-lane, London, E.C. Coupons must be left at the Alliance Bank three clear days for examination.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts of this Company for the week ended December 20th amounted to £788; aggregate receipts for half-year to date, £18,356.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—Application has been made to the Stock Exchange Committee to allow the vendors' shares Nos. 45,101 to 50,000 of this Corporation to be quoted in the official list.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—The Stock Exchange Committee have ordered the vendors' shares Nos. 101 to 2,132, and additional shares Nos. 2,133 to 6,100 to be quoted in the official list.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the half-month to December 15th were £2,514 as compared with £2,559 in the corresponding period of last year, showing a decrease of £45.

FOOTBALL.—SILVERTOWN STAFF v. SIEMENS BROS.—This match was played last Saturday at Charlton before an enthusiastic body of spectators, and resulted in a win for Silvertown by one goal three tries to nil. Tries by Cardell (2), Lumsden, and Daubeny, one of which was neatly converted by P. Evans. The first half of the game was of a fairly even character, but in the latter half Silvertown had matters more in their own hands. Referee, H. Tuson, Wickham Park. Touch judges, W. E. Gray and S. Russell. In the evening both teams, by the kind invitation of Mr. W. E. Gray, dined at the Holborn Restaurant.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Dec. 16.		Price Tuesday, Dec. 22.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Dec. 22.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/6	Anglo-American	50	51	49½	50½	5 3 6	Jan., Apr., July, Oct.	50⅝	49¾
£2,849,510	Stock	25/0	Do. Preferred	88	89	87½	88½	5 15 10	,, ,,	88⅝	88
£2,849,510	Stock	5/0	Do. Deferred	13	13½	12¾	13¼	..	,, ,,	13 3/16	13
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July ..	102	..
130,000	£10	5/0	Brazilian Submarine	11	11½	11	11½	7 2 3	Mar., June, Oct., Dec.	11⅜	11
£68,200	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	145	148	145	148	4 14 7	April and October ..	..	..
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	16	17	16½	17½	5 14 3	,, ,,	16¾	..
12,931	5	2/0	Direct Spanish (£4 paid)	3¼	3⅜	3⅜	3⅜	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9⅜	10⅛	9¼	10⅛	4 15 3	,, ,,	10	..
60,710	20	3/6	Direct United States	10⅞	11⅛	10⅞	11⅛	6 6 2	Jan., Apr., July, Oct.	11 1/16	..
400,000	10	2/6	Eastern	14	14¼	14	14¼	4 11 3	,, ,,	14 1/16	13 15/16
70,000	10	6%	Do. 6 per Cent. Preference	14⅜	15¼	14⅜	15¼	3 18 8	,, ,,	..	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	108	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	109	..
250,000	10	2/6	Eastern Extension	15	15½	15	15½	4 12 7	Jan., Apr., July, Oct.	15¼	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107	110	107	110	3 12 9	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb. 1900	103	106	103	106	4 14 4	,, ,,	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99	102	99	102	3 18 5	Febuary and August	101½	..
180,227	10	2/0	Globe Telegraph and Trust	9⅜	10	9⅜	10	5 7 6	Jan., Apr., July, Oct.	10	9 13/16
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15	14⅜	15	4 0 0	,, ,,	15	14¾
150,000	10	5/0	Great Northern	18¾	19½	19	19½	4 7 2	Jan., April, and July	19	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	42⅝	42
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	7¾	8¼	7¾	8¼	4 16 11	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	117	122	117	122	4 18 4	,, ,,	..	..
15,609	10	6/0	West African Telegraph	7	8	7	8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	97	100	97	100	5 0 0	March & September	98⅝	98⅜
30,000	10	2/0	West Coast of America	3½	4½	3½	4½	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	100	105	100	105	7 12 5	June and December	..	..
88,321	10	1/0	West India and Panama	1¼	1⅝	1⅛	1⅜	..	,, ,,	1⅜	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	8¾	9½	9	9½	6 6 4	May and November	9¼	9⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7	8	7½	8½	7 1 2	,, ,,	..	..
67,007	15	6 0	Western and Brazilian	10½	10⅝	10½	10⅝	6 19 5	,, ,,	10½	10⅜
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6¼	6⅜	6¼	6⅜	5 7 3	,, ,,	6 1/16	6 1/16
30,364	7½	7/6	Do. 5 per Cent. Deferred	4	4½	4	4½	..	,, ,,	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	,, ,,	.	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜	½	⅜	½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16	1/16	1/16	1/16	6 3 11	Yearly	..	..
438,984	5	2/6	National xd	4½	4⅝	4⅝	4⅝	6 9 9	June and December	4 7/16	4 7/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref. xd	12¼	12½	12¼	12½	4 14 1	,, ,,	12⅝	..
15,000	10	6%	Do 6% Cumulative 2nd Prf. xd	12	12½	12	12½	4 16 0	,, ,,	12½	12
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	107	109	107	109	4 2 7	January and July ..	108	..
58,000	5	1/0	United River Plate	1	2	1	2	..	,, ,,	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£6 paid)	5½	6	5½	6	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
8,332	£5	..	House to House Electric	4½	5	4½	5	..	..	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2⅜	2⅞	2⅜	2⅞	..	..	..	..
10,000	£5	3½%	Do. (fully paid)	4⅜	5⅛	4⅜	5⅛	..	..	..	..
111,000	5	..	London Electric Supply	1	1⅛	1	1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9⅛	10⅛	9⅛	10	..	..	10⅛	9 1/16
6,318	10	..	Notting Hill Electric Lighting (fully paid)	6½	7½	6	7	..	..	..	..
18,680	£5	3/6	St. James' and Pall Mall	8⅝	9⅛	8⅛	9	..	..	8⅞	8½
7,900	£5	7%	Do. 7% Preference	7¼	7⅝	7¼	7⅝	..	..	7⅝	..
42,853	5	..	Westminster Electric Supply (£5 paid)	6¼	6¾	6¼	6¾	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/8	Brush Electrical Engineering	3⅛	3⅜	3⅛	3⅜	..	..	3 1/16	..
69,996	2	6%	Do. 6 per Cent. Preference	2	2¼	2	2¼	5 6 8	..	..	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½	6	5½	6	5 16 8	January and July ..	..	..
17,139	5	17%	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	6%	Electric Construction	6½	7	6½	7	..	—	6¾	6 1/16
70,000	2	10/0	Elmore's Patent Copper Depositing	1⅞	2⅛	2¼	2⅜	..	—	3	2⅝
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20½	21½	20½	21½	4 15 3	February & August	21	20¾
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	4	5	4	5	..	..	..	..
11,334	£10	8/0	Do. Preference	8⅜	9½	8⅜	9½	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅜	⅝	⅜	⅝	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	4¼	4⅜	4¼	4⅜	8 2 0	May and November	4 3/16	4⅛
36,250	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July.....	43½	42⅝
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July ..	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2⅛	2⅜	2⅛	2⅜	15 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	3⅜	3⅞	3⅜	3⅞	10 0 0	..	..	..
			RAILWAYS AND TRAMAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	—
50,000	£10	—	City and South London Railway	5		2½	3½	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

A large proportion of the information contained in the statistical pages of our present issue has been afforded to us by the secretaries of the different companies. But there is a limit to the number of questions which these busy men will answer, and many of the figures have been filled in by careful searching through our back numbers. In some cases we have been obliged to leave blanks. The Notting Hill Company, for example, cannot tell us the present capacity of their plant nor the ultimate capacity of their station. Without troubling the companies for figures, which can be arrived at with a revised map of the districts and a planimeter, we have obtained the number of square miles of the different districts which are allotted to the London supply companies. But some of these have large slices of the parks, and those which border on the river trace their boundary along mid-stream. We therefore give a second set of figures for the net area over which lighting may be done, and from these we get the plant capacity in lamps per square mile, which is a measure of the value of the district. The area of St. Pancras is about 4·1 square miles, but so much of the northern part is park and common land that it is impossible to define the portion available for lighting. These figures do not relate to the number of lamps connected, but to the possible output of the present plant.

London Statutory Supply Companies' Districts in order of net area in square miles, exclusive of parks, &c.

	Gross.	Net.
Metropolitan	5·45	4·6
London	4·29	3·37
Westminster	2·56	1·9
Chelsea	1·23	1·13
House-to-House	0·94	0·77
Notting Hill	0·81	0·69
Kensington and Knightsbridge	0·97	0·67
St. James and Pall Mall	0·24	0·24
Electricity Supply	0·43	0·18

Supply Companies in order of plant capacity in lamps.

Westminster	137,000
Metropolitan	95,000
London	90,000
Kensington	50,000
St. James	40,000
Electricity Supply	38,000
Chelsea	30,000
House-to-House	25,000

Supply Companies in order of plant capacity in lamps per square mile (net, exclusive of parks).

St. James	167,000
Kensington	74,600
Westminster	72,100
House-to-House	32,400
London	26,700
Chelsea	26,600
Electricity Supply	21,000
Metropolitan	20,600

The progress of electric lighting in London in 1891 has taken place rather in the number of fresh houses which have been coupled to the supply mains than in the additional streets in which fresh mains have been laid. While there has been a very large increase in the number of lamps attached to the supply company's systems, the additional length of streets, as shown in our map, which is now in an advanced stage of preparation, is remarkably small. On comparing this map with the one we published at the commencement of last year, it will be found that the increase in the streets in some districts is quite insignificant. The Belgravia district of the Westminster Company shows but little alteration, although a very large increase has taken place in the actual number of lamps. The Mayfair and Grosvenor-square district is now thickly covered, and in almost every yard there is fierce competition with the London Electric Supply Corporation. The most notable example of fresh ground covered is the extension of the Metropolitan Company in the Bayswater district. Our map, which we hope to publish on the 15th inst., will show no less than four companies in Coventry-street, which is the boundary of the St. James, Metropolitan, and the Electricity Supply Corporation, and which runs through the extensive district allotted to the London Electric Supply Corporation.

The spread of electric lighting in the residential districts is largely impeded by the uncertain and short tenure of house property. During 1889 about one hundred miles of mains were laid in front of the best houses, and a large number of these availed themselves immediately of the supply, but out of every hundred houses in front of which mains have been laid for a twelvemonth, and which are not yet wired, ninety are likely to remain so until the termination of their present leases. Tenants are reluctant to wire their houses when a comparatively short portion of the lease remains, unless an

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arrangement can be made with the landlord; and, as a matter of fact, there is great difficulty in making such an arrangement. New houses are sure to be wired by the builders if the mains are at hand, and the Chelsea Company has benefited largely by the building operations on the Cadogan estate. It is difficult to see how supply companies can encourage the wiring of houses, as, although a tenant may be willing to pay for the wiring by instalments, should he leave the house; the supply company have no claim whatever upon the incoming tenant, whilst under the terms of the Act he can demand a supply of current. If it could be arranged that the Company could sue him for the use of the wires, this difficulty might be met; but these unfortunately become landlord's fixtures, and the supply companies would be driven to make the best terms they could with the landlord. The majority of landlords are content to keep their houses in a barely tenantable condition; the bursting of water-pipes is frequently treated as reasonable wear and tear to be repaired by the tenant, and electric lighting becomes to be regarded as a mere luxury.

The recent agitation at Cambridge on the subject of "compulsory Greek" threatened at one time to raise an estrangement between men of science and men of letters; but happily so many well-known representatives of the former class threw their influence into that side which may be said to be both liberal and conservative, that this danger was averted. Proving conclusively that much as a thorough education is to be insisted on, and that the University is by no means opposed to the recognition of science, the Senate passed last week, without any opposition, two "graces," one with the view of promoting the development of an Engineering School in the University, and the other to take into consideration the establishment of an honours degree in Mechanical Science. While wishing Prof. Ewing every success in developing the teaching of engineering at Cambridge, we cannot help thinking that the step which the University has taken is more remarkable than a concession on the Greek question. We do not allude to the development of the Engineering School; for the University might encourage the study of farming, navigation, or even financial science; but the establishment of a Tripos, and the granting of an honours degree places not only Mechanical Science but the functions of the University in a new light. The advancement of learning and the continually increasing high pressure and competition of modern life must have its effects on the old Universities as well as on society at large; and while we should greatly regret to see a lessening of the important characteristics which distinguish these bodies from the younger establishments and technical colleges, the object is in this case so excellent that our conservative feelings give way.

The University of Cambridge has granted honour degrees in the Law Tripos for many years; but a graduate in this school is not fitted for an immediate appearance at the bar. And in an excellent leader in *The Times* of Christmas Day, making an appeal for benefaction wherewith to equip a laboratory, it is carefully pointed out that the new Tripos is not intended to supersede practical training. Dr. Fleming followed up this article with a plea for University College, and Mr. Capper for King's College. It is impossible to conceive the extent and direction in which that still immature branch of knowledge called Mechanical Science may develope in a well-equipped laboratory, with not too many students, a few good demonstrators, and an able professor not too much occupied with consulting work.

In no other branch of knowledge have analogies been more extensively used and more actively pushed than in electrical science. They have served a most useful purpose, but we cannot accept them as the premises of a logical conclusion. The comparison made between the three forms of energy present in heat, water-power, and electricity, which will be found in our correspondence columns, is delightfully simple, but fails to convince us. It is asked whether the third resembles the first or the second. Heat *is* energy; but in water-power the product of pounds of water into feet-fall is energy; and in electricity the product of amperes into volts is energy. The resemblance is little else than an accidental one, viz., that the second and third are composed of factors. But the factors are not homologous, and some have been suppressed. Though heat is in itself energy, there must be a difference of temperature or thermo-motive force before we can get work from it; and with water-power we must have gravitation or ponderomotive force before we can get energy. When we say that the product of pounds of water into feet-fall (i.e., foot-pounds) is energy, the "pounds" do not really denote the quantity of water, but the force of gravitation, which is conveniently measured in pounds. It is not, therefore, justifiable to compare the pounds of water—meaning a quantity of water—with coulombs, meaning a quantity of electricity.

We venture to differ with our valued correspondent as to the analogue of the turnstile. In the sentence which he quotes from our leader we implied that there are two distinct ways of measuring a crowd. A turnstile measures them as a current of persons, and, as our correspondent points out, this process may be repeated indefinitely. But we alluded to another way, viz., the collection and counting of the persons not as a current, but as a "static" quantity, and we can find no corresponding mode of measuring electricity unless as the charge in a condenser. But in this case we can easily recognise that the charge may be accounted for by a displacement strain of the ether; no idea of a concrete or material substance is needed. To the question, "Is it matter or is it motion?" we would reply by another question: "What is it that drives the wheels of a watch?" The spring alone will not do it, and the motion of the spring is an effect, not a cause. The proximate cause is the resilience of the spring when strained. We do not need the idea of horology to express the going of a watch, and we can similarly dispense with the idea of electricity. Electricity is not ether in the same way that sound is not air, and horology is not a steel spring.

The single objection which may be raised to the new expression "hindrance," which Mr. Heaviside advocates in our correspondence columns, is that it is not self-explana-

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tory, and a distinct effort of memory is required to connect it with the physical quantity to which it is proposed to attach it, but which it cannot be said to designate or connote. Hindrance is no more explicit than obstruction, restraint, restriction, and has only the merit of being purer English. Mr. Heaviside is fond of coining words like conductance and permittance; and the advantage of these over a dictionary word like hindrance is that the man who coins them has a right to attach them to the idea which they are intended to designate. It is doubtful whether anyone has a right to apply the common word hindrance to the quantity known as L. The word chokage might be suggested as denoting something that is characteristic of a choking coil. To recollect the difference between chokage and impedance it should be remembered that impedance is a word savouring of theory, and that theorists are fond of periodic currents; while a choking coil being an ordinary sort of thing, chokage is applicable to intermittent, transient, and miscellaneous currents.

The Weston voltmeter came in for some high praise at a recent meeting of the Institution of Electrical Engineers, and we have heard it spoken of in the highest terms by people who knew what they were talking about, but who, being interested in the manufacture of electrical instruments, naturally do not care to publish their views. The average electrical engineer, it is to be regretted, is not very familiar with the "points" of a voltmeter; he swears at it, or at the maker, when he finds, always too late, that it has been misleading him; but he too often either knocks it about as he would a lineman's detector, or screws it on a switch-board within a few inches of a main cable. We should hesitate to publish the account of the remarkable experiment which is recorded in another column had not we already heard it described by an eye-witness. Prof. Silvanus Thompson says that English manufacturers know nothing about magnet making, Mr. Preece says that the magnets used by the Post Office are hard to beat; and somebody gets up every now and then with a phenomenal specimen at which everyone who believes him is surprised, but none of whom ever think of sending any orders. The strength and permanence of the magnet in the Weston instrument are its leading features. We hear different accounts about the necessity for occasional recalibration, but are inclined to think that if it were not for a very slender and weak aluminium pointer it would compare well with the best English instruments.

An action which is now pending in the Dundee Small Debts Court is of no little interest to telephone subscribers at large. The National Company is suing a local firm for the amount of their telephone rental, payable in advance, for the period November 1891-92. The defence put in is that any contract which may have been entered into has been voided by reason of the bad telephone service. It is something new to hear of a plea of this kind north of the Tweed, where we are always being told things telephonic are as they should be. If this ingenious defence proves successful, what a terrible instrument of energetic protest lies ready to hand for those London subscribers who are not yet satisfied.

The Elmore Companies do not often come in for kind words. And we were not surprised to hear some scoffing at the wire manufacturing company which has no intention of manufacturing wire, and which pays £5,000 royalty in advance for the right to split up tubes and sell them as sheets. But at the meeting of this Company, which is reported in another column, an announcement was made of an interesting modification of the Elmore process. The tube as it grows is repeatedly exposed to the air, and at each exposure a slight oxidation takes place, sufficiently thin to allow of further deposition, but thick enough to prevent adherence. The resulting tube, being ripped up and flattened, is transformed into "a number of beautifully burnished sheets of perfectly even surface and thickness, and equal in every way to those known to the trade as planished sheet." This is undoubtedly interesting and pretty. Whether it has any more commercial value than other Elmore products we really do not know, and shrink from inquiring.

Obituary.—The death is announced, at the age of seventy of the eminent chemist, Prof. Stas.

Manchester.—It is hoped that in about a month a start will be made with the works connected with the installation of the electric light, which includes the lighting of the Town Hall.

Telegraphic Communication with South Africa. — The Eastern and South African Telegraph Company notifies the restoration of its Aden-Zanzibar cable, thus re-establishing telegraphic communication with South Africa by the East Coast. Both the East and West Coast routes are now in working order.

Camera Club.— We are requested to state that the eighth of the series of One Man Photographic Exhibitions at the Camera Club will be open on and after Tuesday next, from 10 a.m. to 4 p.m., on presentation of cards, which can be obtained from members, or from the Hon. Secretary. The pictures will be on view for about six weeks.

Bristol.—At the meeting of the Town Council last week, it was considered advisable, on the report of Mr. Preece, to pile the whole of the ground, in order to ensure the stability of the central station. The Lancashire boiler, as more suitable for the Bristol water and the local coal, has also been adopted, in place of the one originally recommended.

Featherstone.—At a recent meeting of the Local Board a letter was read from Lord Masham, offering to light up North Featherstone for a term of 15 to 20 years with the electric light for the sum of £20 per year and 4d. per hour during the time the current was used. A resolution accepting the offer was carried. At present the district is lighted by oil-lamps.

City and South London Railway.—The Directors of the City and South London Railway have made a further increase in their fares. The fares from the Oval to any of the intermediate stations are now raised to 2½d. between the hours of 8 a.m. and 10 a.m. This alteration is said to be because of the great traffic at this station, especially when any sports are going on at the Oval.

Personal.—We are informed that from to-day Mr. H. Graham Harris—who has for so many years been principal assistant—will become Sir Frederick Bramwell's partner, and that the business heretofore practised by him at 5, Great George-street will be continued under the style of "Bramwell and Harris," to whom it is requested all letters on matters of business should be addressed.

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The Association for the Improvement of Geometrical Teaching.—We call the attention of those of our readers who are interested in the objects of this Association to the fact that a meeting will be held on Saturday, the 16th inst., at University College, Gower-street. The afternoon sitting will commence at 2 p.m., and several Papers will be read, which will be announced in due course in our Societies' Meetings columns.

Crystal Palace Electrical Exhibition. — It is officially announced that this Exhibition will be formally opened on January 9, 1892. Considerable progress has been made with many of the exhibits, some of which are of considerable magnitude, and it has been found that it would be impossible to have these all in position by January 1st, as was originally intended. We have been favoured with a lengthy list of exhibitors, together with the numbers and positions of their stands.

"Electrical Plant."—Mr. E. R. Dolby informs us that he retires from the editorship of *Electrical Plant* after editing the Special Central Station Number and the ordinary January issue, 1892, and that he will devote his entire attention to his consulting practice at 8, Princes-street, Westminster. Mr. H. Cuthbert Hall, who has acted as Mr. Dolby's assistant for the special number, will undertake the editorship, and the offices of the journal will be at 52, Queen Victoria-street, E.C.

"L'Électricien."—Our Paris contemporary, *L'Electricien*, announces that from to-day it will be under the management of an editorial committee consisting of Prof. Monnier (École Centrale des Arts et Manufactures), Prof. Éric Gérard (Institut Électrotechnique Montefiore), M. Félix Lucas, M. Emile Dieudonné, M. Eugène Meylan, M. Montpellier (founder of the *Révue Internationale de l'Electricité*). The chief object of the appointment of a committee is to secure absolute impartiality.

Liverpool.—The Watch Committee have adopted a resolution that the Town Clerk inform the Board of Trade that the Council object to the Provisional Order applied for by the Liverpool Electric Supply Company; and also that the consideration of the memorial signed by consumers of electricity in Liverpool, requesting the Corporation to give their consent to the application of the Liverpool Electric Supply Company, for a Provisional Order, be postponed until the second meeting in January.

The Glasgow Corporation and Messrs. Muir, Mavor, and Coulson.—After much negotiation, it has now practically been resolved by the Electric Lighting Committee of the Corporation to take over the business and plant of Messrs. Muir, Mavor, and Coulson, who have certainly been the pioneers of central-station electric lighting in Glasgow. At first the lighting was conducted from a low-tension station in Miller-street, chiefly to carry out a contract for the General Post Office in George-square, about 200 or 300 yards distant. In course of time the demand for electric lighting in silversmiths' shops, warehouses, &c., in the centre of the city became so great that Messrs. Muir, Mavor and Coulson were induced to start another central station on the alternate-current transformer system. The number of consumers has gone on increasing until the generating machinery is unequal to the demands made upon it. At the request of the Lighting Committee of the Corporation, Messrs. Muir, Mavor and Coulson stated the terms on which they were willing to make over to the city their property and entire interests as suppliers of electric light from their two central stations, and the sum of £30,000 was named as the amount wanted. Further, they placed their books and balance-sheets for three years at the service of the Committee of the Town Council, the convener of which, acting under the powers given to him, appointed a local accountant to report upon the firm's business and property, as shown by the books and balance-sheets. He also appointed an electrical expert to assist the accountant in making out a correct valuation. The valuation arrived at in this way was under £14,000. Finally, the Committee received a formal offer from the Company to dispose of their whole undertaking for the amount of £15,000. Of course, the terms of the proposed bargain have to be approved of by the Town Council before they become binding, but there is every probability that the whole undertaking will formally pass into the hands of the Corporation by March 1st, 1892.

The Proposed Electric Railways in the Metropolis.—The following additional particulars with regard to the various tubular electric railways, for which it is proposed to obtain powers next Session, may be of some interest:—The Waterloo-City (Mansion House) Railway, which will be 1 mile 4 furlongs 6·8 chains long, is fathered by Sir John B. Simeon, Lieut.-Colonel H. W. Campbell, Major-General Taylor Du Plat, Mr. E. A. Guest, and Mr. Wyndham S. Portal. The proposed capital is £540,000, with borrowing powers up to £180,000. The time for completing the line is, as in all the other cases, five years. The Waterloo-Baker-street (Dorset-square) Railway is fathered by Lieut.-Colonel H. W. Campbell, Major-General Taylor Du Plat, Colonel A. H. Bircham, Lieutenant-Colonel F. D. Gray, and Mr. A. R. Ricardo. A capital of £1,250,000 is proposed. The Finsbury Park (Great Northern Railway) City (Finsbury-pavement) Railway, which is promoted by the Great Northern Railway Company will have a capital of £1,500,000, in shares of £10 each, and the works which it is proposed to execute are (1) a railway 5 furlongs 5·70 chains in length in the parish of St. Mary, Islington, commencing by a junction with the up line of the Finsbury Park and Canonbury branch of the Great Northern Railway and terminating at Drayton-park, Holloway; (2) a railway 1 furlong 1 chain in length, commencing by a junction with the down line of the Great Northern Railway, and terminating at the same point as railway No. 1; (3) a railway 2 miles 5 furlongs 1·4 chains in length, commencing by a junction with the terminus of Nos. 1 and 2 railways, and terminating in the parish of St. Stephen, Coleman-street, at Finsbury-pavement, opposite the north side of West-street. The Hampstead-St Pancras-Charing Cross line does not appear to have got to the Bill stage. Finally, we have two extensions, viz, the Northern prolongation of the City and South London Railway to the Angel, Islington (2 miles 5 furlongs 3 chains), for which some £810,000 will be wanted, with borrowing powers up to £270,000; and the eastward prolongation of the Central London Railway from the Mansion House to Liverpool Street Station, for which £150,000, with borrowing powers up to £50,000, is scheduled.

Telegraphic Communication with Rock Lighthouses and with Lightships.—In a letter to *The Times* of Wednesday, Mr. R. S. Culley sums up the difficulties, frequently alluded to in these columns, which beset the maintenance of telegraphic connections with lightships or with isolated lighthouses. The difficulties are, he says, as follows:—"The lighthouses are exposed to the full force of the waves, which at times run up even to the tops of the towers. The rocks are rough and the sea bottom rough also, so that the position is about the worst possible for a cable, which would be rubbed to and fro and ground against the hard stone, and would, therefore, have to be made very heavy and strong to secure even a short life. Repairs would be difficult. It is possible to repair a cable in the open sea in a favourable situation only in tolerably calm weather. It would require calmer weather still in such a situation. The repairing vessel would have to wait in the nearest available anchorage until a fine day with calm sea occurred, and if such a chance were lost it might be weeks before another day suited. We not infrequently hear that commuication of any sort with a lighthouse has been impracticable during many weeks. How much less then must be the chances of being able to lift and splice a heavy cable in deep water? Lightship difficulties are of a quite different nature; they arise from the constant motion of the vessel and from its swinging with the change of direction of the tidal current four times a day. The ship shifts her position each change of tide, and at times makes a complete circle. These motions are allowed for by the way her moorings are arranged; but a similar arrangement is, to say the least, very difficult indeed for an electric cable."—Lord Salisbury, in reply to earnest representations made to him on the subject, has given an assurance that should the members of Parliament, who for years past have asked for the appointment of a Select Committee to inquire into the subject of electrical communication between the shore and lighthouses, renew their request during the ensuing Session, the Government will offer no opposition to the proposal.

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ELECTROMAGNETIC THEORY.—XXII.

BY OLIVER HEAVISIDE.

(*Continued from page 164.*)

§ 111. The auxiliary vectors just employed in the expansion of a vector into the sum of three vectors having any independent directions, are examples of vector products. Two vectors being given, their vector product is perpendicular to both of them. Of course, disregarding magnitude, there is but one such vector, viz., the normal to the plane containing the given vectors. Nor is the tensor of any consequence in the example in question, for it will be observed that one of the vectors, **l**, **m**, **n**, appears both in the numerator and in the denominator of one of the three fractions in equation (32), so that the values of the fractions are independent of the tensors of the auxiliary vectors.

But *the* vector product of two vectors has a strictly-fixed tensor, depending upon those of the component vectors and their inclination. There is particular advantage in taking the tensor of the vector product of **a** and **b** to be $ab \sin\theta$. Thus we *define* the vector product of two vectors **a** and **b** whose tensors are a and b, and whose included angle is θ, to be a third vector **c** whose tensor c equals $ab \sin\theta$, and whose direction is perpendicular to the plane of **a** and **b**; the positive direction of **c** being such that positive or right-handed rotation about **c** carries the vector **a** to **b**. This vector product is denoted by

$$\mathbf{c} = \mathbf{Vab}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

and its tensor may be denoted by $\mathbf{V_0ab}$, so that we have

$$c = \mathbf{V_0ab} = ab \sin\theta \quad . \quad . \quad . \quad . \quad (34)$$

Similarly $\mathbf{V_1ab}$ may be used to denote the unit vector parallel to **Vab**.

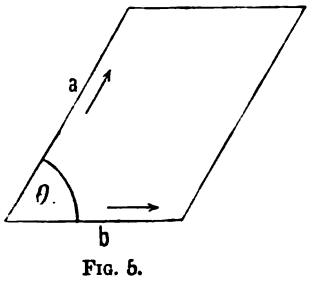

FIG. 5.

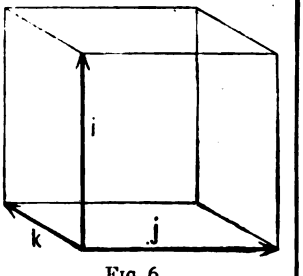

FIG. 6.

The only troublesome part is to correctly fix which way along the perpendicular to the plane of **a** and **b** is to be considered positive. Examples will serve to clinch the matter. Thus, let **a** be towards the north, and **b** towards the east on the earth's surface; then **c** is straight downwards. Again, in Fig. 5, the direction of **c** is downwards through the paper, and its tensor is the area of the parallelogram upon **a** and **b**.

Let **b** be fixed, whilst **a** moves round so as to vary the angle θ. Starting from coincidence, with $\theta = 0$, the tensor of **c** is zero. It reaches a maximum (downwards) when θ is a right angle, and falls to zero again when θ reaches two quadrants, and **a** is in the same line with **b**, though discurrent. After this, in the next two quadrants, the same numerical changes are gone through; but now, the sine being negative, **c** must be upwards from the paper.

The unit reference vectors **i**, **j**, **k** are so arranged that when, in (33), **a** is **i** and **b** is **j**, then **c** is **k**; noting in Fig. 6, that **k** is supposed to go downwards, or away from the reader. Thus, in accordance with our definition we have

$$\mathbf{Vij} = \mathbf{k}, \qquad \mathbf{Vjk} = \mathbf{i}, \qquad \mathbf{Vki} = \mathbf{j}, \quad . \quad . \quad (35)$$

because the mutual angles are quadrants and the tensors unity. Observe the preservation of the cyclical order **i**, **j**, **k** in (35). Also, we have

$$\mathbf{Vii} = 0, \qquad \mathbf{Vjj} = 0, \qquad \mathbf{Vkk} = 0, \quad . \quad . \quad (36)$$

because the vectors paired are coincident.

By the definition the reversal of the order of the letters in a vector product negatives it. Thus

$$\mathbf{Vab} = -\mathbf{Vba}. \quad . \quad . \quad . \quad . \quad . \quad (37)$$

Since the tensor of **Vab** is $ab \sin\theta$ and the scalar product **ab** is $ab \cos\theta$, we have

$$(\mathbf{ab})^2 + (\mathbf{Vab})^2 = (ab)^2. \quad . \quad . \quad . \quad . \quad (38)$$

§ 112. A vector product, being a vector, of course combines with other vectors to make scalar and vector products again. Thus **cVab**, where **c** is any new vector, means the scalar product of **c** and **Vab**; and **VcVab** means the vector product of **c** and **Vab**. These are both important combinations, which occur frequently, and their interpretations and expansions will be given presently. As illustrative of notation, it may be mentioned that $\mathbf{cV_0ab}$, where, as before explained, $\mathbf{V_0ab}$ is the tensor, is obviously a vector parallel to **c**, but $\mathbf{V_0ab}$ times as long. On the other hand, $\mathbf{cV_1ab}$, where $\mathbf{V_1ab}$ is the unit vector, is the same as $\mathbf{cVab}/\mathbf{V_0ab}$; since by dividing by the tensor we unitise the vector. Similarly as regards $\mathbf{VcV_1ab}$. We may also have $\mathbf{V_1cVab}$ and $\mathbf{V_1cV_1ab}$ and $\mathbf{V_0cVab}$, and various other modifications, whose meanings follow from the definition of a vector product and its notation.

We do not often go further in practical vector algebra than combinations in threes; for instance, on to **dVaVbc**, the scalar product of **d** and the previously explained **VaVbc**.

The scalar product **cVab** has an important geometrical illustration. Its value is given by

$$\mathbf{cVab} = \mathbf{V_0ab} \times c \cos\phi, \quad . \quad . \quad . \quad . \quad (39)$$

where ϕ is the angle between **c** and **Vab**. This is by the definition of the scalar product, and of the tensor of a vector.

Now refer to Fig. 5 again. We know that $\mathbf{V_0ab}$ is the area of the parallelogram. We also know that the volume of a parallelepiped is the product of its base and altitude. Construct, then, a parallelepiped whose three edges meeting at a corner are **a**, **b**, and **c**. The area of one of its bases is $\mathbf{V_0ab}$, and the corresponding altitude is $c \cos\phi$. Therefore, by (39), **cVab** is the volume of the parallelepiped.

But there are two other bases and two other altitudes to correspond, so there are two other ways of expressing the volume, giving the equalities

$$\mathbf{aVbc} = \mathbf{bVca} = \mathbf{cVab}, \quad . \quad . \quad . \quad . \quad (40)$$

in which observe the preservation of cyclical order, done to keep the sign the same throughout, as will be verified a little later.

§ 113. The semi-cartesian expansion of $\mathbf{c} = \mathbf{Vab}$ is

$$\mathbf{c} = \mathbf{i}(a_2b_3 - a_3b_2) + \mathbf{j}(a_3b_1 - a_1b_3) + \mathbf{k}(a_1b_2 - a_2b_1), \quad . \quad . \quad (41)$$

in terms of **i**, **j**, **k** and the scalar components of **a** and **b**.

To prove this, multiply (41) by **a** and **b** in turns to form the scalar products **ac** and **bc**. Do this by the rule embodied in equation (23). We get

$$\mathbf{ac} = a_1(a_2b_3 - a_3b_2) + a_2(a_3b_1 - a_1b_3) + a_3(a_1b_2 - a_2b_1),$$
$$\mathbf{bc} = b_1(a_2b_3 - a_3b_2) + b_1(a_3b_1 - a_1b_3) + b_3(a_1b_2 - a_2b_1).$$

But, by cancelling, all the terms on the right disappear. That is,

$$\mathbf{ac} = 0, \qquad \mathbf{bc} = 0.$$

From these we know that **c** is perpendicular to **a** and to **b**. It is, therefore, **Vab** itself, or a multiple of the same. To find its tensor, square (41). We get

$$c^2 = (a_2b_3 - a_3b_2)^2 + (a_3b_1 - a_1b_3)^2 + (a_1b_2 - a_2b_1)^2. \quad (42)$$

But this may, by common algebra, be transformed to

$$c^2 = (a_1^2 + a_2^2 + a_3^2)(b_1^2 + b_2^2 + b_3^2) - (a_1b_1 + a_2b_2 + a_3b_3)^2. \quad (43)$$

That is,

$$\mathbf{c}^2 = \mathbf{a}^2\mathbf{b}^2 - (\mathbf{ab})^2, \quad . \quad . \quad . \quad . \quad . \quad (44)$$

or,

$$c^2 = a^2b^2 - a^2b^2 \sin^2\theta = (ab \sin\theta)^2.$$

The tensor c is, therefore, that of **Vab** itself, or else its negative. Equation (44) is the same as (38), in a slightly different form. Equation (41) is proved, except that it remains to be seen whether the right member represents **Vab** or its negative.

To do this, we may remark that the angle between two planes is the same as the angle between the normals to the planes, if the normals coincide when the planes do, so that the three quantities in ( )'s in (41), which are the scalar projections of **c** on the axes, are also the areas of the projections

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of the area $V_0\mathbf{ab}$ on the planes perpendicular to them. We have therefore only to verify that the projection of any plane on the plane normal to one of the axes is given correctly in sign by (41). Take a rectangle, parallel to the **j**, **k** plane, sides parallel to **j** and **k**, that is, $a_2\mathbf{j}$ and $b_3\mathbf{k}$; so that

$$\mathbf{c} = \mathbf{i}a_2b_3.$$

Here a_2b_3 is the projection of the rectangle on a parallel plane, and is correctly positive.

Now go back to (41). We have

$$\mathrm{V}\mathbf{ab} = \mathbf{i}(a_2b_3 - a_3b_2) + \dots \quad (45)$$

Similarly

$$\mathrm{V}\mathbf{ac} = \mathbf{i}(a_2c_3 - a_3c_2) + \dots \quad (46)$$

Add these together. We get

$$\mathrm{V}\mathbf{ab} + \mathrm{V}\mathbf{ac} = \mathbf{i}[a_2(b_3 + c_3) - a_3(b_2 + c_2)] + \dots \quad (47)$$

But the right member, by definition of a vector product, or by (41), means $\mathrm{V}\mathbf{a}(\mathbf{b}+\mathbf{c})$. That is,

$$\mathrm{V}\mathbf{a}(\mathbf{b}+\mathbf{c}) = \mathrm{V}\mathbf{ab} + \mathrm{V}\mathbf{ac}. \quad (48)$$

Similarly

$$\mathrm{V}\mathbf{d}(\mathbf{b}+\mathbf{c}) = \mathrm{V}\mathbf{db} + \mathrm{V}\mathbf{dc}. \quad (49)$$

So, by adding these again,

$$\mathrm{V}(\mathbf{a}+\mathbf{d})(\mathbf{b}+\mathbf{c}) = \mathrm{V}\mathbf{ab} + \mathrm{V}\mathbf{ac} + \mathrm{V}\mathbf{db} + \mathrm{V}\mathbf{dc}, \quad (50)$$

a very remarkable and important formula. It shows that the vector product of two vectors, **A** and **B**, equals the sum of all the vector products which can be made up out of the component vectors [$(\mathbf{a}+\mathbf{d})$ and $(\mathbf{b}+\mathbf{c})$ in (50)] into which we may divide **A** and **B**, provided we keep the components of **A** always before those of **B**. The necessity of this proviso of course follows from the reversal of $\mathrm{V}\mathbf{ab}$ with the order of **a** and **b**. Although (50) only shows this for two components to each primary vector, yet the process by which it was obtained evidently applies to any number of components.

Subject to the limitation named, the formula (50) is precisely similar to (17) § 108, relating to the scalar products. Now the truth of (17) could be seen without much trouble. A similar proof of (50), on the other hand, would not be at all easy to follow, owing to the many changes of direction involved in the vector products. This is why I have done it through **i**, **j**, **k**, which are auxiliaries of the greatest value. When in doubt and difficulty, fly to **i**, **j**, **k**.

On the other hand, although the establishment of (50) by geometry without algebra is difficult, and there is preliminary trouble in fixing the direction of a vector product, yet we see from (50) that vector products are nearly as easily to be manipulated algebraically as scalar products.

§ 114. By means of the formula (41) we can at once obtain the Cartesian expansion of the parallelepipedal $\mathbf{cVab}$. Use equation (23), applied to (41), remembering that **c** is now any vector, and we get

$$\mathbf{cVab} = c_1(a_2b_3 - a_3b_2) + c_2(a_3b_1 - a_1b_3) + c_3(a_1b_2 - a_2b_1). \quad (51)$$

By rearrangement of terms on the right side of this, putting the a's outside the brackets, we obtain $\mathbf{aVbc}$, and putting the b's outside, we obtain $\mathbf{bVca}$, and thus verify (40) again.

The vector $\mathrm{Vc}\mathrm{Vab}$ is, perhaps, most simply expanded through **i**, **j**, **k**. First write **d** for $\mathrm{V}\mathbf{ab}$, then by (41) we have

$$\mathrm{Vc}\mathbf{d} = \mathbf{i}(c_2d_3 - c_3d_2) + \dots .$$

Next put for d_1, d_2, d_3 their values in terms of a's and b's, given in (41), and we have

$$\mathrm{Vc}\mathrm{Vab} = \mathbf{i}[c_2(a_1b_2 - a_2b_1) - c_3(a_3b_1 - a_1b_3)] + \dots$$
$$= \mathbf{i}[a_1(b_2c_2 + b_3c_3) - b_1(a_2c_2 + a_3c_3)] + \dots$$

Lastly, add and subtract $a_1b_1c_1$, and we get

$$\mathrm{Vc}\mathrm{Vab} = \mathbf{i}[a_1\mathbf{bc} - b_1\mathbf{ac}] + \dots$$

Lastly, reconvert fully to vectors, and we have

$$\mathrm{Vc}\mathrm{Vab} = \mathbf{a}.\mathbf{bc} - \mathbf{b}.\mathbf{ca}. \quad (52)$$

This important formula should be remembered. That $\mathrm{Vc}\mathrm{Vab}$ is in the plane of **a** and **b** is evident beforehand, because $\mathrm{V}\mathbf{ab}$ is perpendicular to this plane, and multiplying by Vc sends it back into the plane. It is, therefore, expressible in terms of **a** and **b**, as in (52), which shows the magnitude of the components.

In some more complex formulæ it is sufficient to remember the principle upon which they are founded, as by its aid they can be recovered at any time. Thus in the case of

$$\mathbf{r} = f\mathbf{a} + g\mathbf{b} + h\mathbf{c}, \quad (53)$$

already treated, equation (31), if we use now $\mathrm{V}\mathbf{bc}$ for **l**, which was before any multiple of it, and similarly for **m** and **n**, we have

$$\mathbf{r} = \frac{\mathbf{r}\mathrm{V}\mathbf{bc}}{\mathbf{a}\mathrm{V}\mathbf{bc}}\mathbf{a} + \frac{\mathbf{r}\mathrm{V}\mathbf{ca}}{\mathbf{b}\mathrm{V}\mathbf{ca}}\mathbf{b} + \frac{\mathbf{r}\mathrm{V}\mathbf{ab}}{\mathbf{c}\mathrm{V}\mathbf{ab}}\mathbf{c}. \quad (54)$$

There is no occasion to put a formula like this in the memory, because it is so simply obtained at any time from (53) by multiplying by the auxiliary vectors so as to isolate f, g, h in turn and give their values.

Notice that the three denominators in (54) are equal. Also that by exchanging **a** and $\mathrm{V}\mathbf{bc}$, **b** and $\mathrm{V}\mathbf{ca}$, **c** and $\mathrm{V}\mathbf{ab}$, we obtain

$$\mathbf{r} = \frac{\mathbf{ra}}{\mathbf{a}\mathrm{V}\mathbf{bc}}\mathrm{V}\mathbf{bc} + \frac{\mathbf{rb}}{\mathbf{b}\mathrm{V}\mathbf{ca}}\mathrm{V}\mathbf{ca} + \frac{\mathbf{rc}}{\mathbf{c}\mathrm{V}\mathbf{ab}}\mathrm{V}\mathbf{ab}, \quad (55)$$

and this is also true, as we may at once prove by multiplying it in turns by **a**, **b**, and **c**, each of which operations nullifies two terms on the right. (55) is the expression of **r** in terms of three vectors, which are normal to the three planes of any three independent vectors, **a**, **b**, **c**, taken in pairs. Here, again, such a formula can be immediately recovered if wanted by attending to the principle concerned.

To obtain the cartesian expansion of any formula containing vectors is usually a quite mechanical operation. The cartesian, or semi-cartesian, representatives of a few fundamental functions being remembered, their substitution in the vector formula is all that is required. If the formula be scalar (although involving as many vectors as we please) the result is a single scalar formula in cartesians. But if it be a vector formula, it reduces to a semi-cartesian vector formula involving **i**, **j**, **k**, giving three scalar equations, one for each component.

The converse process, to put a scalar cartesian investigation into vectorial form, is less easy, though depending upon the same principles. Here the three component equations have to be reduced to one vector equation. It is very good practice to take a symmetrically written-out cartesian investigation and go through it, boiling it down to a vector investigation, using the unit reference vectors **i**, **j**, **k**, whenever found to be convenient.

(To be continued.)

ON THE CONSTRUCTION OF A BATTERY OF MINIATURE ACCUMULATORS.*

BY C. L. WEBER.

To charge electrometer needles, and for similar laboratory work, a Zamboni dry pile, or a battery of Voltaic cells, is usually employed. Such appliances, useful for static effects, are useless when a current is taken out of them. If miniature Planté accumulators are used their capacity is but small. For the calibration of torsion galvanometers, voltmeters, &c., and for measuring the insulation resistance of cables or electric light circuits a battery is often required which shall retain a constant E.M.F. of 100 volts, with an external resistance of 10,000 ohms; in other words, a battery is wanted which shall be able to yield a curreut of about 10 milliamperes. The author has recently constructed for the Munich testing laboratory, a battery capable of furnishing such a current for 36 hours.

The cells are made up in stout glass test tubes, 11 cms. high and 1·6 cm. in diameter. The spiral electrodes are formed of lead wire 1·5 m.m. in diameter and 50 cms. long. These spirals are arranged as shown in the figure, and are filled with active material. The leading-in wire of the lower electrode is protected by a piece of glass tubing. A paste composed of minium and sulphuric acid is put into the lower spiral, the upper one containing a litharge-sulphuric acid paste. The paste should be left to dry for about 24 hours before pouring in the electrolyte. The 60 cells of the battery were mounted in groups of 10 between two glass rods, supported at the ends by wooden uprights the tubes being kept vertical and separate by india-rubber bands. The whole battery can be enclosed in a box 29 × 16 × 18 cms.

This 60-cell battery is charged from the electric light mains in three parts, a liquid resistance of between 1,000 and 5,000 ohms

* Abstract from *La Lumiere Electrique*.

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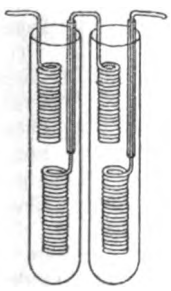
being interposed in the circuit, so that at the commencement the current is only 20 milliamperes; it is, however, gradually run up to 100 milliamperes, which is equivalent to about 30 milliamperes per group.

After having been formed and duly charged, the battery having been carried about and made considerable use of, was discharged for 36 hours through a resistance of 10,000 ohms. At the commencement of the test the terminal E.M.F. was 120 volts, and at the end of the test 100 volts.

The battery can easily furnish more powerful currents. Thus, in the above test the discharge current was at first 48 milliamperes, though at the end of seven hours it had fallen to 35 milliamperes. It has even been discharged at the rate of 65 milliamperes. The normal charge is 30 to 40 milliamperes for 20 hours. The loss of charge is small. At the end of a charge the E.M.F. was found to be 120 volts, and at the end of a week it was still 110 volts. This battery possesses a high capacity for its size, and may, therefore, prove of use for testing purposes.



Before finally settling on a definite mode of construction the author made a few experiments with regard to the disposition of the active material. He made up four groups, each of three cells, the lead spirals were all identical, but contained different quantities of active material. The four groups were all submitted to the same *régime*, and an initial current of 10 amperes being taken out of each set the time which this current took to fall 7 per cent. was noted :—

—	I. No active material.	II. + Electrode empty. − Electrode litharge.	III. Both electrodes litharge.	IV. + Electrode minium. − Electrode litharge.
Terminal volts ..	8·8	7·0	6·4	6·3
Duration of discharge, in minutes	2	19	39	67

ELECTRIC LIGHTING NOTICES.

The following is a list, corrected up to date, of the Electric Lighting Notices for 1892. It will be seen that in all 17 Local Authorities and 25 Companies are applying for Provisional Orders; the grand total being 32, as against 70 for 1890. An asterisk denotes that the gas works are the property of the Local Authority.

THE METROPOLIS.

Districts.	Names of Applicants.
County of London (North).	County of London Electric Lighting Company.
County of London (South).	County of London Electric Lighting Company.
Hackney	East London Electric Supply Company.
Hampstead.....	Vestry of St. John, Hampstead.
Lambeth.....	Vestry of Lambeth.
North London...	Camberwell & Islington Electric Light and Power Supply.
St. Mary, Islington.	Messrs. Sharp and Kent.
Shoreditch	Vestry of Shoreditch.
South London...	Camberwell & Islington Electric Light and Power Supply.
West London...	Putney and Hammersmith Electric Light and Power Supply.
Whitechapel ...	Board of Works for Whitechapel District.

Total number of applications 11, of which 4 are by Local Authorities.

PROVINCES.

Towns, &c.	Names of Applicants.
Aberystwith ...	Corporation.
Ashton-under-Lyne.	Corporation.
Brighton.....	Brighton and Hove Electric Light Company.
Dublin..	Corporation.
Fareham	Fareham Electric Light Company.
*Govan	Commissioners of Police.
*Halifax	Corporation.
Harwich	Corporation.
Horswell and Chertsey.	Woking Electric Supply Company.
Kilkenny.....	Corporation.
*Limerick	Corporation.
Liverpool	Liverpool Electric Supply Company.
Maidstone	Corporation.
*Newbury	Corporation.
†Oxford	Oxford Electric Company.
Sheffield	Sheffield Telephone Exchange and Electric Light Company.
Sutton (Surrey).	Urban Sanitary Authority.
Walton-on-Thames.	Weybridge Electric Supply Company.
Waterford	City of Waterford Electricity Supply Company.
Waterford	Corporation.
West Ham	Corporation.

Total number of applications 21, of which 13 are by Local Authorities.

† Transfer of Order of 1890 from Electric Installation and Maintenance Company.

THE ELECTRIC RAILWAYS AND TRAMWAYS OF THE UNITED KINGDOM.

Place.	Length.	System.	Worked by.
In Operation—	Miles.		
Barking	1¼	Accumulator Cars	General Electric Power and Traction Co.
Bessbrook—Newry...	3¼	Third Rail (Dr. E. Hopkinson)	Bessbrook and Newry Tramway Company.
Birmingham	3	Accumulator Cars	Birmingham Central Tramways Company
Blackpool	2	Holroyd - Smith's Conduit	Blackpool Electric Tramway Company,
Carstairs	1¼	Anderson - Munro	J. Monteith, Esq., of Carstairs.
City and S. London Rail. (King William-st.–Stockwell)	3¼	Third Rail (Dr. E. Hopkinson)	City & South London Railway Company.
Croydon	3¼	Accumulator Cars (Jarman)	Croydon Tramways Company.
East Pool (minerals)	1½	Telpherage	..
Guernsey.....	2¾	Overhead (Siemens)	Guernsey Railway Co.
Leeds (Roundhay Park Line)	3¼	Thomson-Houston Overhead	Mr. Graff Baker.
Portrush — Giant's Causeway	8	Third Rail (Siemens)	Giant's Causeway Electric Tramway Co.
Ryde	¾	Third Rail (Siemens)	Ryde Pier Company.
Southend Pier	¼	Third Rail (Crompton)	Local Board.
In Progress—			
Central London Rail. (City and Shepherd's Bush)	6	...	Central London Railway Company.
Liverpool Overhead Railway	6¼	Third Rail	Electric Construction Corporation.
Stockwell and Clapham	1	...	City & South London Railway Company.
Wellingborough and District Tramroads	2½	...	Wellingborough and District Tramways Company.
Projected—			
Bradford.....	...	Experimental.....	Mr. Holroyd-Smith.
Brecon.....	...	...	Town Council.
Darlaston	23	Overhead.....	Staffordshire Steam Tramways Co.
London—			
Central London Railway (Extension)	½	...	Central London Railway Company.
City and S. London Railway (Islington Extension)	2½	...	City & South London Railway Company.
Hampstead, St. Pancras & Charing X.	5¼	...	...
Finsbury Park & City	3¼	...	...
North Metropolitan Tramways	...	...	North Metropolitan Tramways Company
Waterloo–Baker-st.	2¾	...	...
Waterloo Station—City	1½	...	South Western Railway Company.
Walsall	...	Overhead	Walsall Electrical Co.
Wigan.....	5½	...	Wigan Tramways Syndicate.

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1891.

The twelve months that have elapsed since, in accordance with a useful and time-honoured custom, we last took a brief retrospective glance at the leading events in the electrical world, have been marked by a steady advance, not, however, without frequent breaks in the monotony which generally accompanies such a state of things. Electricity has been rightly dubbed the "Imperial Science;" and as this proud title is made good as much by the discovery and assimilation of new facts as by the forcible and sometimes premature annexation of branches of physical science hitherto free and independent, the events of 1891 will be found, like those of previous years, to have contributed several additional justifications for our claim to empire. Hertzian oscillations are now part of the stock in trade of that great and growing army of electro-technical students, the ranks of which become every day more hopelessly crowded; while EWING'S molecular theory of induced magnetism, by reason of its extreme plausibility and beautiful experimental analogue, has long been accepted as something axiomatic, and has been embodied in the latest edition of every respectable text-book. Electricity, from the pure science point of view, was therefore in some little danger of becoming dull, when it was announced to the scientific world, through the strange medium of *The Times*, that oxygen at −180°C. had been discovered by Prof. DEWAR to be highly magnetic. *A priori* this was to be expected; but an ocular demonstration of the correctness of our theoretical deductions is always a welcome event. Again, while the commonplace lamp maker was patiently awaiting the expiry of the Edison-Swan patents, and the central-station manager was speculating whether the market price of incandescent lamps would then be twelve or eighteen pence, Mr. NIKOLA TESLA, skating on the thin ice which in America so often separates pure research from commercial experimenting, gave us a tantalising glimpse of an ideal mode of illumination by means of bulbs devoid of filaments and made to glow by being placed in a rapidly-

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alternating electrostatic field. At Cambridge, almost contemporaneously, Prof. J. J. THOMSON was upsetting all our preconceived notions as to the fitness of things by bringing out a transformer with no core and no copper, upon the practical possibilities of which, however, he, unlike his friendly competitor across the Atlantic, laid no stress whatever. In commercial electricity also, if we have not all become "drehstromers," the advent of the polyphase-current machine has shown us that the *ultima Thule* of dynamo design has not yet been reached, and that "extra high pressure" is not necessarily limited to 10,000 volts. The past year cannot, therefore, be added to the long list headed—devoid of interest.

This time last year it was by no means certain whether municipal electric lighting had come to stay; at the end of 1891 there is but little doubt that it will be a permanent feature in the municipal economy of the United Kingdom. It is indeed true that although nearly one hundred Orders have now been granted to Local Authorities, at the most only about a dozen of them can be said at present to be seriously taking the matter up; nevertheless, if we make allowance for the inertia inherent to the parochial mind, and remember the praiseworthy determination of many municipalities not to be rushed into taking a leap in the dark, it must be admitted that during the past twelve months municipal enterprise in this direction has not been backward. Early in the year the Dublin Corporation definitely plunged into electric lighting on the alternate-current transformer system, the scheme involving, as all municipal schemes should, a considerable amount of street lighting; the Dublin station is expected to get to work early this month. In Glasgow there has been a prolonged fight between the advocates of high and low pressure; and what with the gratuitous advice of a local evening newspaper on the one hand, and the more expensive counsel of Mr. R. E. CROMPTON, Prof. JAMIESON, and Sir WILLIAM THOMSON, on the other, the well-meaning ediles of that city have been completely befogged. In its hour of perplexity the municipality has sought the support of Prof. A. B. W. KENNEDY; and the able engineer to the Westminster Electric Supply Corporation will doubtless lull any qualms which the members of the Lighting Committee may have as to the suitability of the low-pressure system for supplying the needs of the industrial metropolis of Scotland. Bristol, with leisurely deliberation, proceeded some two years ago to take good advice on electric lighting matters; and on March 10th last £66,000 was voted towards a 10,000-light station on the alternate-current transformer system; street lighting to be represented by 100 arcs. The Bristol Electric Lighting Provisional Order was granted by the Board of Trade in 1888, yet at the end of 1891 the walls of the generating station were not above ground. At Cambridge, the question of municipal electric lighting, once on the verge of settlement, appears at the time of writing to have been, at any rate, temporarily shelved; the Local Government Board being strongly of opinion that drainage should precede electricity. Huddersfield has entered into a contract with the Brush Company for the erection of a central station, and both Manchester and Nottingham have decided to spend large sums on electric lighting. Nottingham is as yet committed to no definite scheme; but Cottonopolis is apparently ready to pin its faith on that complicated intricacy known as the five-wire system. During the autumn two municipal stations came into operation, namely, those of Brighton and St. Pancras, both on the low-pressure system. At Brighton electric lighting matters are a little out of joint, the original estimates have been exceeded, and the opposition is gathering strength. At St. Pancras all is reported to be as it should be. And here with mention of the fact that Portsmouth, Leicester, and several other towns are bestirring themselves, we must conclude the chronicle of municipal electric lighting in 1891. So far as contractors are concerned, the Local Authorities, it is clear, cannot be too energetic in undertaking their own electric lighting. But for the industry, as a whole, and looking into the future as well as at immediate advantages, it is as yet too early to assert that mere public spirit and the fear of the spasmodic tantrums of the ratepayer will conduce to as good results as the bracing atmosphere of healthy competition and the necessity of declaring a dividend. Everything that appertains to the health, safety, and public convenience of the community is undoubtedly within the scope of municipal enterprise, so that street lighting may well be undertaken by a Vestry or Town Council. No one proposes under ordinary circumstances to separate private and public lighting from each other, so we arrive by a process of ratiocination at the municipalisation of electricity.

To the central-station engineer the Metropolis has, as hitherto, been the principal focus of activity. No less than four stations have been added during the year to the list of those at work within the four-mile radius. In March the Westminster Electric Supply Corporation actively entered the field; and at the end of May the Notting Hill Company, on a less ambitious scale, followed suit. The total number of generating centres now in operation in London under statutory conditions is twenty, with a total capacity at the present moment of over 550,000 lights. A little more than twelve months ago Mr. FRANK BAILEY, of the Metropolitan Company, in a Paper read before the Society of Arts, gave the number of 8 c.p. lamps connected to the mains of the various London supply companies at 179,060. With the augmentation in plant and main capacity which has taken place during 1891, it will not, perhaps, be too hazardous to add about 50 per cent. to this figure, and to estimate the aggregate number of lamps now connected at 300,000 Our London central-station companies have not, however, been merely content to add to their capital outlay, but in one instance, at any rate, a substantial dividend has been declared. The decision of Mr. Justice KEKEWICH with regard to transformer sub-stations, to which we adverted last week, and the slow progress of the City lighting, to which general allusion has been made, need no more than a passing mention here.

In his Paper read before the Institution of Civil Engineers in April, Mr. CROMPTON set an example which it is, perhaps, not too much to expect will be more generally followed as time goes on. It is for the good of the lighting industry as a whole to bring down the price of the Board of Trade unit to the lowest figure compatible with an adequate return upon capital and an efficient service; and nothing would conduce more to the attainment of this object than a little less reticence on the part of our more prominent central-station managers. No one knows until he has tried what a mass of information useful to the electrical engineering community at large may be published in Papers or otherwise, without running any serious risk of "giving oneself away."

Electric traction still continues to make progress of that slow but sure description so dear to the English nation. The general adoption of electricity on urban tramways seems as far off as ever. At Leeds Mr. GRAFF BAKER has been plucky enough to give us a somewhat dubious blessing in the shape of a plain undiluted specimen of the American overhead trolley system. Mr. BAKER appears to have imported a consignment of his native characteristics, together with his cars, T.H. single-reduction motors, and other Yankee "notions;" for, despite the changed environment, he has already had a miniature

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"smash," and is now "in interference" with the National Telephone Company. All who admire pluck will wish him well out of his difficulties. As to accumulator cars, it can only be said that they are still awaiting the perfect tramcar battery. The system is being tried on an important and practical scale at Birmingham, and, in spite of the very bad track on which the cars have been placed, the service is satisfactory, and the next statement of accounts will be looked for with interest. On the other hand, when we come to heavy work such as railways overhead or underground, or interurban tramways, the air is full of contracts concluded, or about to be concluded, and of projects to run steel tubes here, there, and everywhere. The Central London Railway scheme, which this summer met with the approval of the Upper House of the Legislature, has now reached the experimental borings stage, At Liverpool they have contracted with the Electric Construction Corporation to work their overhead railway at 3½d. per train mile (locomotive expenses); and on the South Staffordshire Tramways steam will e'er long give way to electricity. As to the tubular railways projected in London, they one and all meet decided wants. The City and South London Railway, when it has got its northern extension, will probably prove a more decided financial success; but it is to be hoped that before then a remedy will have been found for the mechanical or electrical defects which at present disturb the regularity of its train service and the equanimity of its patrons.

In the telephone world we have had a particularly eventful year. In February the Mutual Company commenced its attack on the telephonic monopoly by the opening of an exchange at Manchester. In March the laying of the St. Margaret's Bay-Sangatte cable, under exceptionally unfavourable meteorological conditions, was the last link in the telephonic chain connecting London with Paris. After the formal exchange of international courtesies customary on these occasions the wire was on the 1st of April thrown open to the public, who can now speak through to Paris for three minutes for the not exorbitant sum of eight shillings. The line has been extensively used, and, thanks to the care and skill of the Post Office officials on either side, speech is excellent. The success of this cable is very noteworthy, since it was designed on the strength of calculations, and in the full knowledge that these calculations are at variance with mathematical theory. The whole responsibility of the undertaking rested on Mr. Preece. No preliminary experiments were possible, since speech would be out of the question when the cable was coiled. It differs altogether in this respect, as a bold feat of electrical work, from the Lauffen-Frankfort transmission, or the thirty miles of Ferranti concentric mains. Had speech been difficult, no one but Mr. Preece would have been blamed, and we should have heard much about the heterodoxy of the K R. law. According to some official statistics just published there were 1,222 three-minute conversations in April, 1,491 in May, 1,709 in June, 1,988 in July, 2,276 in August, 2,811 in September, and 2,782 in October. The first seven months' working of the London-Paris telephone trunk line has thus resulted in 13,789 messages and in receipts amounting to £5,491. Into such favour has the service grown that the existing circuit is inadequate to the demands made upon it, and another will be brought in use as soon as possible. The chronic grumbling which the London telephone service evokes has been emphasised during 1891 by the formation of an association for the protection of telephone subscribers, by a remarkably significant warning from the late Postmaster-General, and by the threatened competition of the resuscitated New Telephone Company. Meanwhile the National Company continues to slowly but successfully improve its metropolitan system, and to absorb, in piecemeal fashion, the telephonic network of the country, its last willing victim being the not too prosperous South of England Telephone Company. The United States Patent Office, however, provided us with *the* event of the year, by issuing on November 17th last a patent applied for in June, 1877. Of the Berliner microphone patent, and all its history, our readers will by now have had enough. The most notable feature of the now uneventful history of submarine telegraphy was the all-round reduction in the Australasian cable rates on May day. In August our Continental cable system was added to by the laying of the Bacton-Emden cable, and many of the Submarine Cable Companies have added to their systems by the laying of additional lines. At home our land lines continue as of yore to be more and more used, but the rate of increase is steadily diminishing. The agitation for an organised system of telegraphic communication with our lighthouses and lightships gains continually in strength, and further inquiry into the matter has been practically promised.

Litigation, we are rejoiced to say, has not been particularly rife. The year began with the action brought by the British Tanning Company, owning the Worms and Balé electric tanning patents, against Mr. Groth; and we were treated to much instructive judicial argumentation on the nice question as to whether or not a pit with a framework of hides revolving within it is the mechanical equivalent of a revolving drum in which the hides are tumbled. Eventually it was decided that the Groth process did not infringe that of the British Tanning Company, and that moreover the Worms and Balé patent must be invalidated on a point of law. The effect of the latter part of the decision was, however, subsequently annulled by the passing of a special Act of Parliament rehabilitating the patent. In May the petition for the prolongation of the Jablochkoff distribution patent No. 1966 of 1877 was rejected, the strange discovery being made that one edition of the printed specification was dated differently on the face and on the cover. During the year the Lane-Fox distribution patent has been fitfully before the Courts; but up to now Mr. Lane-Fox has not been successful in bringing his adversaries to close quarters, although he has scored on several preliminary points, and managed to induce the St. James and Pall Mall Company to accept a licence from him as early as last January. In England, Mr. Brush's claim to be the inventor of compound winding is still being weighed in the scales of justice; in America, *per contra*, he has become the legal inventor of the Faure accumulator, and "thus the whirligig of time brings in his revenges."

The scientific societies, it is needless to say, have in 1891, as in previous years invited Papers, received Papers and had Papers thrust upon them. Whether the results are commensurate with the energy expended is open to question. The Civil and not the Electrical Engineers secured the two most practical Papers of the year, namely, that by Messrs. Ll. B. and C. Atkinson on "Electric Mining Machinery," and that by Mr. Crompton on "The Cost of the Generation and Distribution of Electrical Energy." At the Institution of Electrical Engineers Prof. Crookes began the year with a most brilliant Presidential address, and he was followed by Mr. Swinburne on "Transformer Distribution," Dr. Fleming on "Some Effects of Alternating Current Flow in Circuits having Capacity and Self-Induction," and Mr. Preece on "The Specification of Insulated Conductors for Electric Lighting and Other Purposes." During the discussion on Mr. Swinburne's Paper we heard for the first time of the alleged decrease in the iron losses of a transformer as the copper losses increased. This assertion gave rise to much contro-

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versy, the last word of which has been Prof. Ewing's experiment, described in our issue of December 4th.

Among the events of the year we must not omit to mention the successful and instructive Electrical Exhibition on the Main; nor the striking and in many ways remarkable transmission from Lauffen on the Neckar to Frankfort. The Board of Trade Electrical Standards Committee, with its protracted deliberations, and epoch-marking decisions, deserves a place, and a very large one too, in the notes of any self-respecting chronicler. Major Cardew's humble underground laboratory has been busy with preliminary work, but is still waiting for its full equipment. The Faraday centenary celebrations at the Royal Institution in June were not less characteristic of the great man whom they commemorated, and of the country to which he belonged, than were the more boisterous celebrations in Germany which marked Helmholtz's seventieth birthday. Even a cursory annual review such as this would not be complete without some reference, however brief, to the losses which electrical science and industry have sustained during 1891. In May, Edmond Becquerel, a notable figure in the ranks of French *savants*, passed away. On the last day of the same month, David Brooks, better known, perhaps, in telegraph circles than to electric light engineers, died at Philadelphia. In June, Wilhelm Weber, the associate of Gauss, died at the ripe age of eighty-seven. In July, submarine telegraphy mourned the loss of Mr. Willoughby Smith; and by the death, in October, of the Abbé Jean Caselli land-line telegraphy lost an almost equally well-known pioneer; and to this list must be added the name of John Louis Crossley, of telephone transmitter fame, who died at Halifax at the end of August. "Years following years steal something every day; At last they steal us from ourselves away."

THE PRINCIPLES OF ALTERNATE CURRENT MEASUREMENT.

BY HUGH ERAT HARRISON, B.SC.

(*Continued from page 198.*)

Self-Induction.

Let P and Q (Fig. 8) represent two metal rings with a common axis. The ends of P are left open, but the ends of Q are connected with some source of current.

If a current C is sent round Q, lines of force will pass through it, many of which will also pass through P, all of them having emerged from the surface of the conductor Q.

Consider the line l_2 now passing through both rings; originally it was a little circle l_1, whose centre O was in the conductor, and its plane perpendicular to Q at O. This line increased in size until it developed into the line l_2, still a closed curve, but of such size that only a small portion of it can be shown in the figure. During its growth this line must have cut through P at some point O′, and the same applies to all the other lines, originally springing from points in Q, which now thread their way through both rings.

When a line of force cuts a conductor, it sets up, in that conductor, electromotive force; the line l_2, in cutting through O′, sets up an electromotive force at O′ downwards, and it will be found that all the lines set up E.M.F. in the same direction round P as they cut through it in turn. If an electrometer of sufficient delicacy were constructed and connected to the ends of P, an E.M.F. would be indicated all the time P is being cut, that is, all the time C is changing. The moment C becomes steady the lines of force cease to move, P is no longer being cut by them, and no matter how large C may be, no indication will be given by the electrometer.

When the current falls to zero the lines of force which always form closed curves collapse, fall back into Q, and in so doing cut through the various points in P again, but in the *reverse* direction, and the E.M.F. set up by this fresh cutting will also be *reversed*.

Suppose N to be the number of lines which pass through P when one ampere flows in Q, then N C lines pass through when C amperes flow. If the current took t seconds to rise from zero to C, the lines have cut P at an average rate of N C/t lines per second. If E is the average E.M.F. set up, then $E = 10^{-8} N C/t$.* During the next three seconds, suppose the current rises to C′; N C′ will be the total number of lines in P, that is, N (C′ − C) additional lines have cut in, and the average E.M.F. set up during the three seconds is $E = 10^{-8} N (C' - C)/3$.

It must be noted that the value of E has nothing whatever to do with the strength of the current, but is proportional to the *change of strength of current per second*.

If P has now a current sent through it while Q is connected with the electrometer, similar effects will, of course, be produced. A rising current in Q sets up an E.M.F. in the opposite direction in P, a falling current in Q sets up an E.M.F. in P in the same direction as that of the current; *mutatis mutandis*, the same happens as the current rises and falls in P.

Suppose the rings connected up (Fig. 9), so as to form a coil of two turns, the same current will pass through both. When the current rises the lines of force from Q which cut P, set up an E.M.F. in P which opposes the flow of the current in P, and at the same time the lines from P which cut through Q set up an E.M.F. opposing the flow of current in it also.

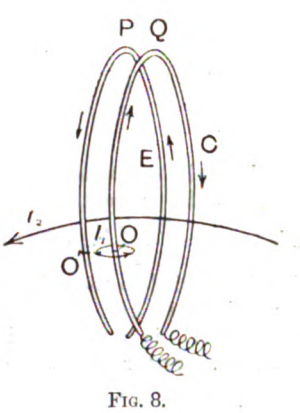

Fig. 8.

Fig. 9.

Indeed, the effect is the same as though a little local battery or dynamo machine were placed in each turn of the coil hindering a rising current, helping a falling current. This property, which a circuit possesses, of producing a local E.M.F. within itself when the current changes, is called "self-induction," and the coefficient of self-induction of a circuit is the value of the average E.M.F., measured in volts, set up when the current changes by one ampere in one second. The coefficient of self-induction is measured in secohms; the E.M.F. set up in a coil when the current changes at the rate of one ampere per second gives its coefficient of self-induction, measured in secohms.

This coefficient is a quantity easy to measure, but frequently next to impossible to calculate.

If the coil (Fig. 9) has n turns, each of these turns will be cut by the lines from $(n - 1)$ others, so that there will be nearly $(n - 1)$ times the original E.M.F. set up in each turn; and, as there are now n turns instead of 2, the E.M.F. will be roughly n^2 times as great as that previously set up in P or Q; hence, as the turns increase, the coefficient of self-induction increases with great rapidity.

With an unvarying current the effects of self-induction are *nil*; it is only since alternating currents have come into use for the distribution of electrical energy that the inductance of a coil may be of even more importance than its resistance.

Suppose a current is made to rise uniformly from zero to 4 amperes in a coil whose resistance is 2 ohms, during 8 seconds; to remain constant for a short period; and then to fall to zero at the same uniform rate. If time, current, and E.M.F. are represented in the same manner as in Fig. 3, the broken line

* The factor 10^{-8} has to be introduced owing to the numerical relations between the volt and ampere and the corresponding absolute units.

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O A B D (Fig. 10) pictures the current, which does not vary during the interval of time $t_1 t_2$, and since by Ohm's law the E.M.F. driving a current is equal to the product of the value of the current into that of the resistance of the conductor, O A_1 B_1 D got by multiplying the ordinates of O A B D by 2, the resistance of the coils, gives the E.M.F. producing the current at each instant. If, however, the coil has a coefficient of self-induction of, say, 1·4 secohm, the E.M.F. O A_1 B_1 D is, while the current rises or falls, the resultant or algebraic sum of two electromotive forces, viz., the E.M.F. applied to the ends of the coil, and the local E.M.F. due to self-induction set up within the coil itself.

The rates at which the current rises and falls are At_1/Ot_1 and Bt_2/t_2D, both of which are equal to $4/8 = 0{\cdot}5$, so that the E.M.F. due to self-induction is in each case $1{\cdot}4 \times 0{\cdot}5 = 0{\cdot}7$. With a rising current this E.M.F. acts against it, and is, therefore, shown by a line F G parallel to and drawn at a distance 0·7 below O T, while H K, representing the E.M.F. due to self-induction, when the current falls, is a line parallel to O T but drawn 0·7 above it.

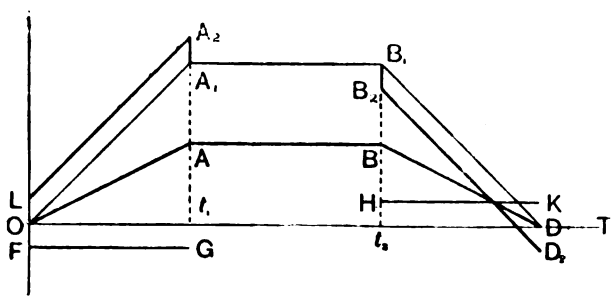

Fig. 10.

Let E = E.M.F. applied to the ends of the coil at any instant while the current is rising, and let C = the current flowing at the same instant; then by Ohm's law $C = \frac{E - 0{\cdot}7}{2}$, so that $E = 2C + 0{\cdot}7$, that is to say, the E.M.F. applied to the coil is 0·7 volt higher than that merely required to get the current through the resistance, and this E.M.F. is represented by the line L A_2, whose ordinates are 0·7 greater than those of OA_1.

Similarly the line B_2 D_2, whose ordinates are everywhere 0·7 less than those of B_1 D, pictures the E.M.F. applied to the bobbin when the current dies away, since the E.M.F. of self-induction acts with a falling current.

While, however, the current is unvarying, E = 2 C simply because self-induction does not come into play at all.

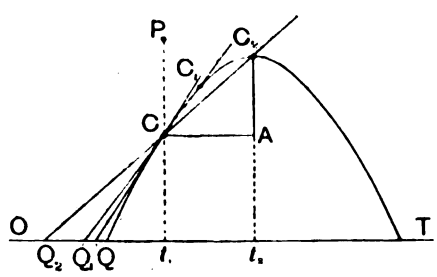

Fig. 11.

The application of the construction just given to the case of a current, whose *rate of variation* changes, is quite simple. Let Fig. 11 represent a single pulse of the alternating current previously referred to. Its value increases from t_1 C to $t_2 C_2$ that is by the amount A C_2 (if C A is drawn parallel to O T) during the time $t_1 t_2$, and its average rate of increase is $A C_2/t_1 t_2 = \frac{A C_2}{CA} = \tan C_2 Q_2 T$.

From the shape of the curve it is clear that the current increases less rapidly at C_2 than at C, and if a point C_1 nearer to C than C_2 be taken, the average rate of increase between the points C and C_1, that is, tan C_1 Q_1 T, approximates more closely to the rate of increase at C than the former value; finally, if a point so near to C as to be indistinguishable from it is taken, the line C Q becomes a tangent to the curve at C.

To find, therefore, the rate of change of the current at any instant, draw a tangent C Q to the curve at the point C under consideration, and note the tangent of the angle C Q T which this line makes with O T.

The value of the tangent of this angle can then be set off as the ordinate t_1P. In Fig. 12 the dotted line is the curve thus traced by a series of points P. This rate of variation curve, V, drawn for a sine curve, is itself a sine curve cutting

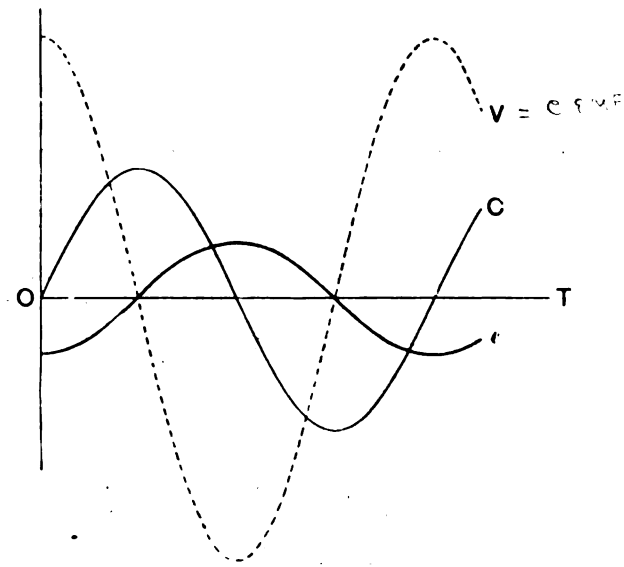

Fig. 12.

O T half way between the points where the current curve C cuts it. If the current is supposed to be flowing through a coil whose coefficient of self-induction is 0·25, multiplying the ordinates of the curve V by the coefficient of self-induction and reversing, the curve e is obtained showing the E.M.F. set up in the coil fron this cause.

Multiplying the ordinates of the current curve C (Fig. 13), by the resistance of the coil, the curve $\mathcal{E}$ is obtained showing the actual or resultant E.M.F. producing the current. If E is the E.M.F. between the terminals of the coil at each

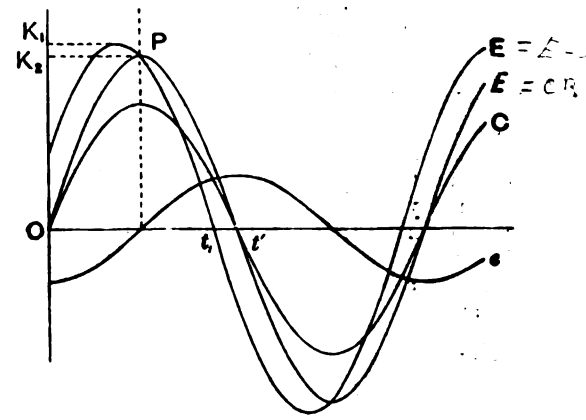

Fig. 13.

instant, $\mathcal{E} = E + e$, therefore, $E = \mathcal{E} - e$, and by subtracting the ordinates of e from those of $\mathcal{E}$ at each point, the curve E can be drawn.

E may be supposed to be the E.M.F. between the mains, proceeding from an alternating-current dynamo machine, across which the coil is connected. E will, therefore, be referred to as the E.M.F. in the mains.

The relative sizes of the curves in such a circuit can, of course, vary to almost any extent, but the relative positions are always the same. The relative positions of C, e, and $\mathcal{E}$, have already been explained; but it must now be noted that since when C, and therefore when $\mathcal{E}$ has its greatest value, $e = 0$, the curve E must always cut curve $\mathcal{E}$ at its highest point P.

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The chief effects of self-induction in an alternating-current circuit are plainly shown in Fig. 13. The effect of self-induction is to reduce the E.M.F. producing the current in the ratio O K_2/O K_1, and the current is therefore reduced in like ratio.

Again, it will also be noticed that C has its greatest and least values at an interval of time, $t_1 t'$ later than the E.M.F. in the mains, and the current is therefore said to lag after this E.M.F.

Choking Coils.

The usual electromotive force provided by public supply companies on house mains is roughly 100 volts. If this voltage is too high for a lamp or other piece of apparatus through which one of their customers wishes to send a current, it can be reduced by placing a resistance coil in series with the apparatus in question.

To take an exceedingly simple case. Suppose a very large incandescent lamp, using 10 amperes and requiring 50 volts between its terminals, to be placed on a 100-volt circuit. If a coil of 5 ohms resistance is put in series with the lamp it will use up 50 volts. The number of watts used up by the combination is 10,000; of these 5,000 are usefully employed in incandescing the lamp, and 5,000 are uselessly employed in heating the resistance coil. Although no conductor has absolutely zero coefficient of self-induction, resistances may, nevertheless, be wound whose coefficient is negligible for most purposes. If this is the case in the present instance the coil may be used with equal effect for an unvarying or alternating current.

With an alternating current it has been shown (*see* Fig. 13) that a coil with self-induction reduces the effective E.M.F. by producing an E.M.F. differing in phase from that of the E.M.F. in the mains. The superfluous 50 volts can, therefore, also be got rid of by means of a coil with a suitable coefficient of self-induction. A coil used in this manner is called a *choking coil*. It is, of course, impossible to wind a coil with no resistance, but a choking coil can be wound whose resistance is small compared with that which the corresponding resistance coil would have. To simplify matters the resistance of the choking coil will consequently be neglected.

Suppose there are 100 complete vibrations of the E.M.F. per second; if the volt be taken as the unit of E.M.F., the second the unit of time, and the centimetre the unit of length; the E.M.F. curve for a half vibration would be about 150 centimetres high, standing on a base 0·005 centimetre long, that is, one whose height would be 30,000 times its width, a curve practically impossible to draw.

One way out of the difficulty would be to take ten volts as unit E.M.F. and say 0·001 second as unit of time. The curve would then be about 15cms. high and 5cms. wide, a fairly manageable size; and the required result being obtained from the curve, it could be multiplied by the necessary factor to get the real numbers.

Perhaps a simpler way still is to solve a problem similar to that about to be considered; assuming the maximum E.M.F. between the mains to be 10 and the number of complete vibrations to be 1 in 10 seconds, to find out how this E.M.F. can be reduced to a maximum of five at the lamp terminals, then to obtain, by simple arithmetic, the quantities required for the real lamp circuit.

Draw the curve E (Fig. 14), whose maximum height [E] equals 10, to represent the E.M.F. between the mains. This has to be reduced to one-half; draw, therefore, the line A B parallel to O T, where O A equals 5. It was shown in Fig. 13 that the resultant E.M.F. curve is cut at its highest point by curve E, which lags behind it; B is therefore the highest point of this curve, and it can now be drawn. As this curve has previously been got from the current curve by multiplying its ordinates into the resistance of the circuit, it may be called the C r curve where C is the current flowing and r the resistance of the lamp. The E.M.F. due to self-induction is greatest when C, and therefore C r, is zero; hence the top or bottom of the e curve occurs at the point of time t_1, where, the resultant E.M.F. being nothing, the E.M.F. of self-induction exactly balances that in the mains; hence, if t_1 D equals t_1 F, D is the lowest point on the e curve, which can now be drawn, cutting O T at t_2, where C r is a maximum.

If t_1 D is measured its length will be found to be 8·7 nearly. From this it appears that an alternating E.M.F., whose maximum value is 10, can be reduced to half by means of a choking coil that gives an E.M.F. of 8·7, when the current passing through it is varying most rapidly, that is, when its direction is reversing.

It is important to note that the number 8·7 is independent of both the current and the number of alternations per second.

It is now easy to find the coefficient of self-induction necessary for the case originally taken.

If the alternating E.M.F. measured on a balance is 100, the maximum height of the curve representing it would be found to be 141·4; but to make Fig. 14 of manageable size, the maximum E.M.F. between the mains and the lamp terminals were reduced to 10 and 5 volts respectively. To make the heights of the curves in Fig. 14 represent the true E.M.F., their ordinates would have to be multiplied by 14·14, making 8·7 × 14·14 = 123. The actual current taken by the lamp is 10, so that the maximum height of the current-curve would be 14·14.

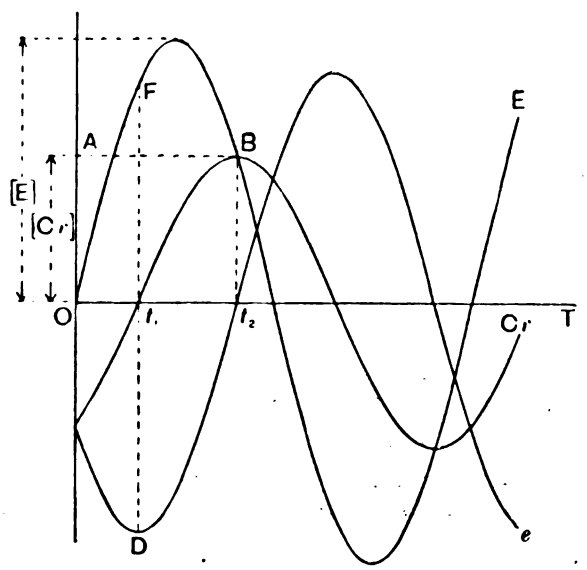

Fig. 14.

Now, a simple sine curve ($y = \sin x$) is 1cm. high and 3·14cms. wide, the angle at which it cuts the axis of x is 45deg., that is, its rate of increase is tan 45deg.; if the height of this simple curve is increased to 14·14, its rate of increase at the same point becomes 14·14 tan 45deg.; finally, if its width be diminished from 3·14 to ·005, the curve is now the required current-curve, and the rate of change as it crosses O T is 14·14 × 3·14/·005 tan 45deg. = 8886 nearly. If S equals the required coefficient of self-induction of the coil, 123 = S × 8886 ∴ S = 123/8886 = 0·0138.

The electromotive force between the mains could be reduced to 50 between the lamp terminals, either by the introduction, in series with the lamp, of a coil with no coefficient of self-induction and of 5 ohms resistance, or a coil with no resistance and a coefficient of self-induction of 0·0138 secohm.

(To be continued.)

THE WESTON DIRECT-READING ALTERNATING AND CONTINUOUS CURRENT VOLTMETER.*

Mr. Edward Weston several years ago invented a type of measuring instrument which embodied in its construction a permanent magnet and a movable coil, which moved in the gap included between the poles of the field-magnet and a soft-iron core. This combination formed practically a closed magnetic circuit, which experience has proved to be practically absolutely permanent in its nature. In proof of this we need only cite an experiment, which was as follows: A continuous-current voltmeter of the Weston type was attached to a circuit reading 100 volts, and by

* From the *Electrical Engineer* of New York.

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bringing a magnet in contact with the poles of the magnet of the instrument itself, so that the N. and S. poles respectively came in contact, the reading of the instrument was changed from 100 to 22. The magnets were then struck repeated blows with a hammer in order to facilitate any change which might take place in the condition of the magnet of the instrument. The auxiliary magnet was then withdrawn, whereupon the needle resumed its original indication of 100 volts within one-tenth of a division, proving practically that no sensible change had taken place in the condition of the magnet.

The experiment was then tried of increasing the strength of the instrument magnet by placing the N. pole of the auxiliary magnet in contact with the N. pole of the instrument magnet, both S. poles also being in contact. The increase in the field thus brought about served to throw the index off the scale. The shocking of the magnets was then repeated, but, upon withdrawal of the disturbing magnet, the index resumed its first position within less than one-tenth of a division. A more crucial test could not be devised to show the permanency of the magnets employed by Mr. Weston in his well-known type of instrument. Indeed, Mr. Weston goes even so far as to place greater reliance in his instruments than in the tangent galvanometer.

With this success gained in the field of continuous-current instruments, Mr. Weston proposed to himself the problem of constructing an instrument of like accuracy and permanency which could be used equally well on circuits carrying either alternating or continuous currents. In casting about for the best principle upon which to construct such an instrument, Mr. Weston, after much thought, turned to the application of the principle embodied in the electro-dynamometer—that is, a fixed coil acting on a movable coil ; but the mere selection of this principle by no means gave the solution of the problem. It must be evident that in order to be equally applicable to both continuous and alternating currents, the instrument must have practically no self-induction. How to obtain this condition with coils carrying alternating currents may be said to have been the problem solved by Mr. Weston. Starting with the fact that the self-induction of such a system depends primarily upon the strength of the current and the number of turns in the coils, Mr. Weston at once set himself the task of reducing the current required to operate the instrument to the smallest possible amount. The corollary to this was, to construct the instrument so that its moving parts should have the least possible weight, and that the friction should be reduced so as to make the instrument as sensitive as possible. To what degree Mr. Weston has succeeded in fulfilling these conditions will be apparent when we state that the moving coil, pointer, springs, and pivots of the new instrument weigh together only 31 grains, that is, less than one-fourteenth of an ounce.

The new instrument is made in two types with single and double scale. Fig. 1 represents the single-scale instrument.

The most essential part of the instrument, of course, is the system of fixed and movable coils, the latter being shown enlarged in Fig. 2. The movable coil consists of copper wire ·002in. in diameter. The diameter of the coil is 1¼in., and it is wound so that it presents a ¼in. square section, consisting of 525 turns. As the proximity of any considerable quantity of metal near the coils would introduce disturbing factors, it became necessary to avoid the use of a supporting spool for the wire of the movable coil, which, upon trial, was found to be quite stiff enough without a spool. The pivots upon which the coil turns are attached to it by means of small aluminum plates, which are first cemented to the coil and then wound with silk thread. The pivots consist of hardened steel, which are ground to gauge and polished. The entire movable system, as stated above, does not exceed 31 grains in weight.

It might be urged that the weight of the coil could have been still further reduced by the employment of aluminum wire ; and this, as a matter of course, also suggested itself to Mr. Weston. Indeed, his first instruments actually embodied aluminum wire coils, but it was found that aluminum could not be drawn practically below ·005 or ·006 of an inch, although Mr. Weston himself has, with great care, succeeded in drawing it down to ·00325 ; but as a still finer wire was needed in order to meet the requirements of the case, Mr. Weston was obliged to fall back upon copper, aluminum being employed wherever possible in the other parts of the movable system. It will be noted that the coil is balanced practically for all positions in the same manner as a watch balance, and, as in the magnet type of Mr. Weston's instruments, acts against the force of very delicate springs which also serve to carry the current to and from the coil.

It will also be noticed that the coil is provided at its lower end with a disc which constitutes part of the friction device provided for the purpose of damping the instrument. It will be evident that, as above stated, the placing of any metal near the coils to effect damping would cause injurious reactions. In the same manner magnetic damping was not permissible, as it would cause the indications to differ with the rate of frequency of the alternating current ; hence it became necessary to control the instrument by mechanical means in order to bring the parts quickly to rest. The brake in the instrument illustrated is combined with the contact-key shown as the hard rubber knob in Fig. 1. The brake normally presses against the disc and holds the moving parts rigid. When the key is depressed the current is first turned on, and then the friction is gradually reduced just sufficiently to allow the coil to gradually move along until, by the time the key is fully depressed, it has reached the position due to the action of the current and

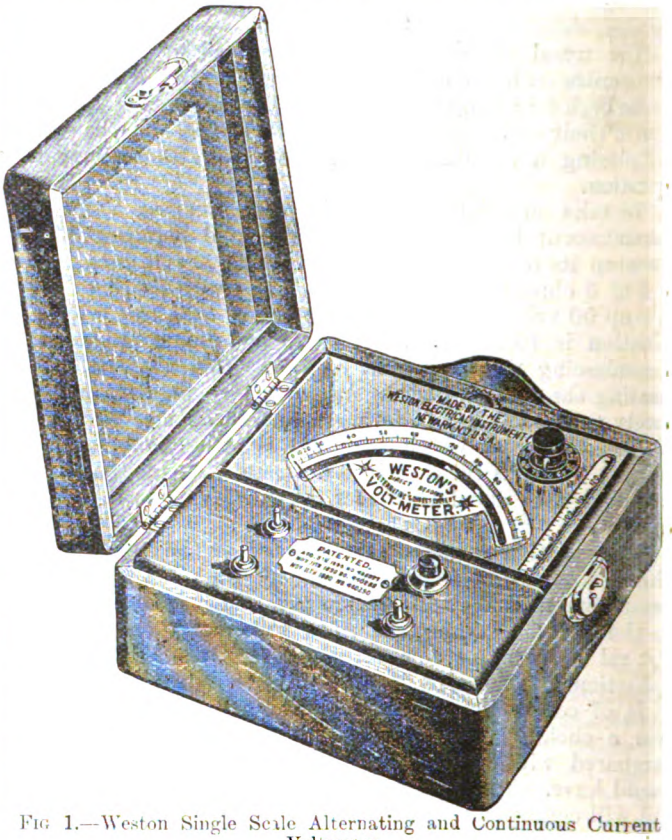

Fig. 1.—Weston Single Scale Alternating and Continuous Current Voltmeter.

indicates the proper reading on the scale. Thus while the instrument in itself is not dead-beat, the means provided by the brake allow readings to be taken nearly as quickly as with a dead-beat instrument.

The stationary coil which surrounds the movable one just described, consists of wire ·003 inch in diameter, the number of turns of which is as small as possible compatible with securing the necessary field of force, the coil being wound on a very thin hard rubber shell. The amount of current needed to move the index

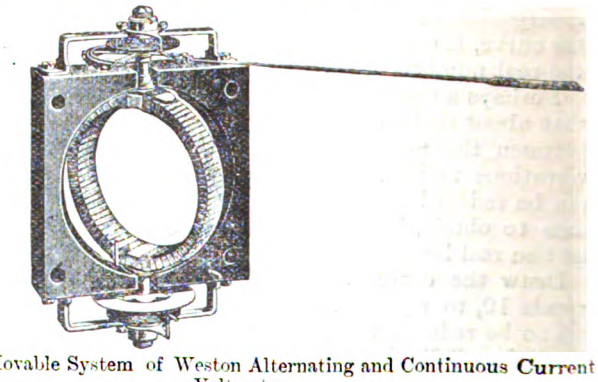

Fig. 2.—Movable System of Weston Alternating and Continuous Current Voltmeter.

across the entire scale differs somewhat in the various ranges made, varying from ·02 to ·056 of an ampere in the two-scale instrument, with the lower scale reading to 60 volts and the upper to 120. The resistance of the instruments averages for 60 volts about 1,100 ohms, and for 120 volts about 2,200 ohms. In single-scale instruments the resistance is generally much higher and the current lower. The principal resistance is in the form of a non-inductive resistance coil outside of the operative system, which is placed in series with the latter, the movable and fixed coils also being in series.

Not the least important part of the instrument is the means afforded by it of obtaining correct readings at all ranges of working temperature. It is a common practice of instrument makers to

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attach to their instruments a table giving the temperature corrections, based merely on the changes in the resistance of the copper coils in the instruments; but it by no means follows, as will be presently shown, that such corrections will give accurate results, and, that, indeed, the indications may vary very largely from the truth when so corrected. While it is true that an increase in temperature of 5°F., for instance, increases the resistance of copper by about 1 per cent., a like change of temperature in the magnetic system of an instrument may cause changes which may be either positive or negative in their nature, according to the type of instrument. In Mr. Weston's magnetic voltmeters the relationship is such that the increased resistance due to increased temperature in the wire is almost exactly counterbalanced by an increase in the magnetic system, due to elevation of temperature. Consequently the instrument itself compensates almost perfectly for the change in resistance of its coil, due to changes in temperature. The new alternating-current instrument has decided the fact that it was impracticable to compensate directly for both of these sources of error; but there is added a thermometer, the bulb of which extends over and comes in contact with the coils, and is so flattened and contains such a small amount of mercury as to give quick response to the slight changes in temperature of the coil. The stem of the thermometer is placed below the glass cover, and can be easily read.

The compensation for changes in temperature is provided for by means of a minute rheostat shown at the right-hand corner of the instrument, which has a dial graduated into 20 parts, each indicating a change of 2½° F., and the whole extending between 60 and 100° F. This provides for a change in temperature of 50deg., which is sufficient for all practical purposes. To compenseate for temperature, therefore, it is only necessary to note the reading on the thermometer and to turn the pointer of the rheostat to the mark corresponding to the temperature indicated by the thermometer. The actual changes in the resistance due to temperature are small, as a large proportion of the resistance is German silver, less than one-tenth of it being copper.

A question which many will ask regarding the instrument is, Will the indications vary with currents of different number of alternations? The practical elimination of effects of self-induction as described above is the best answer to this question. Experiment has shown that no difference can be detected in the readings of this instrument between a perfectly continuous current and one varying from that up to 300 alternations per second, a range covering all practical systems of distribution in use at the present time, and proving the instrument to be practically without self-induction.

THE PROBABLE FUTURE OF CONDENSERS IN ELECTRIC LIGHTING.*

BY JAMES SWINBURNE.

It is always difficult to foretell the future in electrical engineering work, but it is sometimes interesting to try to see in what direction developments are likely to take place.

The first idea of the use of condensers was to employ them like storage batteries, and mention is frequently made by the early electric light patentees of their proposed use in this way. It is needless to remark that these inventors had not the most remote idea of the vast electrostatic capacities needed for storing by the hundred ampere hours.

The project of using condensers instead of transformers is by no means dead. It has been recently taken up on scientific principles by Mr. Doubrava. As soon as a condenser is charged and discharged rapidly enough its size becomes manageable, and Mr. Doubrava is therefore working out a system in which condensers take the place of converters. This development is in good hands, and need not be discussed further. One great difficulty is in charging condensers with direct currents. A condenser of the capacity of a farad charged with one volt contains, if the expression be allowed, only half a joule. If a condenser is charged by being connected to leads at one volt half a joule is wasted over resistance and the other half is stored. The only way of charging the condenser without loss is to connect it with an electromotive force which is gradually rising. Similarly, in discharging, the electromotive force must fall gradually. This condition is not at all difficult to attain.

The greatest development of the use of condensers will probably be in connection with alternating currents. It is doubtful whether ingenuity will ever design an arrangement of condensers that will take the place of transformers in practice. In one sense there is better material to work upon. A transformer is always inefficient on account of hysteresis. The loss by "soaking in" may be taken as analogous to the loss by hysteresis, but it is infinitely less in comparison. For instance, a condenser that takes 2,000 volts and 10 amperes has a loss which is too low to measure—that is to say, it is less than 5 or 10 watts. This loss is proportional to the size of the condenser, so that small sizes are just as efficient as large ones. In transformers this is not the case. A 100,000 watt transformer has a loss of from somewhat less than 1,000 up to about 5,000 watts according to the design, and if the 100,000 watts is made up of a number of small transformers the loss is much greater.

The uses for condensers are already developing. In the first place, they can be used to supply magnetising or exciting currents to all sorts of machinery, and also to apparatus that takes lagging currents. It must be remembered that the magnetising current in any receiving apparatus means a demagnetising current in the generator. As an example that will soon be common, and is also striking, we may take that of running arc lamps off 100-volt circuits with choking coils in series with them. As far as the lamp is concerned, there is no better arrangement than running it off a 100-volt circuit with a choking coil in series with it to reduce the terminal pressure to about 30 volts. If such a lamp takes 10 amperes, the apparent power taken is 1,000 watts, but the real power is probably less than 300 watts. The dynamos at the station have thus to supply large "idle" currents. These not only lead to armature heating, but also demand extra excitation. If many arc lamps are used, more dynamos become necessary, as no machines will stand three times their normal armature currents, even though they are out of step with the electromotive forces. Such currents, therefore, lessen the plant output, or, as as it is often loosely called, the "plant efficiency." To overcome this trouble, all that is necessary is to place condensers in shunt to the choking coils and lamps, or in shunt to the high-pressure leads. The last arrangement is best, as it admits of arranging the condensers at the central station. In addition to this, condensers for 2,000 or 1,000 volts are easier to make than those for 100 volts. Condensers for such low pressures cost too much in tinfoil, and are somewhat bulky, because the dielectric has to be made thick in proportion, to make certain of the absence of flaws. At present comparatively few arc lamps are run in this manner, but that is because nearly all the alternating-current systems now in use have small transformers in houses and high-pressure mains about the streets. This barbarous custom is rapidly going out of fashion. It has taken people a long time to realise that there is an appreciable waste of power in house transformers, and high efficiencies were always quoted, the losses in the copper alone being considered. The loss in the iron is more generally understood now, and the sub-station system is coming into use. This involves automatic gear, and, though certainly an improvement on the old methods, is hardly likely to live long. The system of avoiding loss by automatic gear is bound to go as soon as makers alter their designs and make their transformers more efficient at light loads. The feeder system will then prevail. A high-pressure feeder will then have a transformer at the other end feeding into a low-pressure network. The transformer will have so little loss that it will not be worth while to switch it out of circuit during the day. Even if automatic gear is used, it is not necessary to employ a complicated system of switches. An automatic switch in the secondary, which is controlled by the current in the primary, is all that is required. On breaking the primary circuit at the station, the switch opens the secondary. On making the primary, the secondary makes itself. Whichever method comes into use, it is probable that arc lights will be run off 100-volt circuits with choking coils, and condensers will be required at the stations. Of course, there is no reason why arc lights should not be run off high-pressure circuits by means of constant-current transformers. This system has never come into use in this country, probably because the low cost of this method is not generally appreciated.

It may be well to give some idea of the size of a condenser. One cubic foot of condenser will take about 2,000 volts and 5 amperes, or 10,000 apparent watts. With higher pressures the volume necessary is slightly less, and with low pressures the size increases. Below about 500 volts the bulk increases rapidly, as the volume of tinfoil is greater. The cost, therefore, increases too. It is possible to make condensers very much smaller than this; but while they are new it is best to allow a large factor of safety. Choking coils and constant-current transformers for arc lamps are not the only things requiring exciting currents. Transformers, especially if made with open iron circuits, take "idle" currents, and this can be supplied in the same way. Nearly the whole of an open-circuit exciting current can be supplied by condensers. There is always some left over, because the E.M.F. never varies exactly harmonically. Even if it did, there is some loss in the iron, so the no-load current cannot be reduced to nothing. In a closed-circuit transformer the no-load current is less to begin with, but the active component is much greater, so that it cannot be reduced so much by condensers. It can generally be about halved.

The next use for condensers, which is analogous to those already described, is in connection with motors. Of course it is a little difficult to say what the alternate-current motor of the future will be like. If it is a synchronising machine, with the magnets

* From *Industries*.

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excited by a direct current, it may take a leading or a lagging current, or one in step with the pressure. If it has field-magnets excited by an alternate current it will take a lagging current, and condensers will be necessary. Nearly all the multiple-current motors take large exciting currents, so condensers will be necessary in their case. Take the case, for instance, of the Dobrowolsky 2 H.P. motor, as it is the only case whose figures have been published; at no load it takes 70 volts and 30 amperes at 35 periods per second. This current is presumably in both circuits, so that the apparent power is 4,200 watts; at full load it takes 70 volts and 100 amperes in each circuit, or 14,000 apparent watts. It, therefore, requires two condensers to reduce the apparent watts to about a tenth of these values. The enormous exciting current taken by this form of motor is one of its greatest disadvantages. A condenser to supply 14,000 apparent watts at a frequency of 35 would have a volume of 4 cubic feet. If the frequency is raised to 100 the exciting current increases at approximately the same rate, and so the condenser remains the same size. As there is some difficulty in making the large low-pressure condensers, it is best from that point of view to put the condenser on the high-pressure side of the transformer. This, unfortunately, demands that the transformer should be ten times the size. Thus, a 2 H.P. motor of this type would demand a 20 H.P. transformer at a frequency of 35, or a 60 H.P. at 100 periods per second. The transformers are nearly the same size in these two cases. The enormous size of the transformers is a great drawback to machines excited by alternate currents, and, unless multiple current motors can be greatly improved, this fault alone would be enough to render them useless for most work.

So far the condenser has been described as arranged in shunt to the circuit containing self-induction. It has then no effect on the circuit with self-induction, but affects the dynamo. In fact, it supplies exciting current, instead of letting the dynamo supply it. The self-induction can, however, be counteracted by arranging capacity in series with it. For instance, suppose the alternate machine is made like one for direct currents, except that the field-magnets are laminated. Suppose the machine in question is a 10-H.P. motor for 100 volts. If the field-magnets are wound to suit 100 volts on a direct-current circuit, they will be only very slightly excited by the alternating pressure. If the number of turns is much reduced and the diameter increased, full excitation will eventually be reached, but the current will be enormous. For instance, if the magnets take 2 amperes on a 100-volt direct-current circuit, the loss in copper is 200 watts; but to drive 2 amperes through the inductive circuit with an alternate current would probably need something like 5,000 volts. If a few turns of large wire are used instead, the full excitation will probably be reached with about 100 amperes. Not only is the exciting current enormous, but the armature current is not in step with the field induction, therefore the output is also lessened from this cause. M. Leblanc was the first to point out a method of overcoming these troubles by the use of condensers. A condenser may be put in series of such a capacity that at the frequency employed the E.M.F. of the condenser is always exactly equal and opposite to that of the self-induction of the magnets. This condition can only be attained approximately, since the pressure does not vary perfectly harmonically. If it did, all the E.M.F. of the supply circuit would be spent on resistance, so that the same current would be produced as if the magnets were excited by a direct pressure. The field induction is then in step with the E.M.F., so that the armature current is so also, and the power taken by the motor is found by multiplying the pressure by the current.

Messrs. Stanley and Kelly have designed and worked out a motor on this principle. It is constructed like an ordinary direct-current shunt motor, but has laminated field magnets. A condenser is arranged in series with the magnets. This motor has some drawbacks. In the first place, if the field magnets and armature are on a 100-volt circuit, the pressure on the condenser and on the field coils will be something like 5,000 volts, and this might make the motor too dangerous for admission to private premises. Of course, this depends on the size and design of the motor. It may be possible to design a machine with much lower condenser pressure. The loss by hyteresis in the field magnets is also necessarily large; but that is not such a serious matter in a motor as in a transformer which is in use day and night. The next trouble is sparking at the brushes. The armature coils are short-circuited just at the time of the most rapid change of field, so that there is a large current in the short-circuited section. I would suggest that this trouble can be overcome by winding the armature with two separate circuits in parallel. The brushes then collect from both, but never short-circuit any of the sections.

The Tesla motor, as is well known, demands two or more currents differing in phase. Two currents differing a quarter of a period will suffice. At first special dynamos with double-armature circuits were used as generators, but several arrangements involving condensers have been proposed. The first experiments of this kind were probably made by Prof. Ayrton and Dr. Sumpner. They had a small Tesla motor some years ago, but made up some arrangement with self-induction and capacity so as to split a single current into a double one. The experiments have not been published, therefore I do not know what the exact arrangement was. Mr. Tesla has designed numerous arrangements himself; but the most complete investigations have been made by MM. Leblanc and Hutin, and those interested in this subject will do well to read the able articles in the *Lumière Electrique* which have been appearing recently at short intervals. Those authors have gone most carefully and exhaustively into the whole subject of alternate-current motors of all sorts, and their Papers are very suggestive. In one a very simple arrangement is due to them. One field-magnet circuit has a condenser in series with it. Its current and induction are therefore in step with the pressure, and the wire used is the same as for direct currents under the same pressure. The other magnets, however, are wound with few turns of low-resistance wire, and take a large current, which lags practically a quarter of a period behind the pressure. In all practical cases a lag can be adjusted to a quarter of a period by using a condenser of the right capacity in the first circuit.

It is to be feared that there will be great difficulty in working out this system to be right at various loads. As the load increases, an active current should flow in both circuits. The circuit with the condenser in series with it cannot take its load current, so that the full load output in this form of motor may be little more than half that of a double-current motor of the same size. It is probable, however, that the ingenuity of MM. Hutin and Leblanc, in France, or Mr. Tesla, in America, may overcome this drawback. A multiple-current motor is, however, thus obtained, which will work on ordinary supply circuits Only one of the sets of magnets takes a large "idle" current; but to avoid trouble from this the use of a second condenser in shunt to the mains or to the transformer that supplies the motor is advisable. This condenser is of the same cubical contents as the first, but unless arranged on the high-pressure side of the transformer it is designed for a much lower pressure and for a correspondingly larger current. By this means a self-starting motor can be obtained which has no brushes, which works on an ordinary supply circuit, and which gives full torque on starting. It has, however, the same drawbacks as the type first described. The dangerous pressure on the field coils of the first circuit may be reduced by arranging the magnet coils in small portions alternately. If the fields take 5,000 volts to drive the exciting current through, say, twelve coils, the coils and portions of the condenser may be arranged alternately, so that the maximum pressure is just over 400 volts due to the condensers. The fall over the resistance of the circuit is out of step with this, and may therefore be neglected. Mr. Tesla has also patented an arrangement on the same principle as MM. Hutin and Leblanc. He uses one field circuit partly as a transformer to transform up, and then places the condenser in the secondary circuit. This seems rather to increase the difficulty arising from the very high pressures resulting from arranging condensers and induction coils in series. He has also put a condenser in the armature circuit, but it is difficult to see the inventor's object in this. Whether this form is the motor of the future or not is difficult to say; but if it is, the number of condensers required will be considerable, so we are justified in discussing it at some length in this article.

There is still another possible use for condensers, and that is for exciting dynamos. An alternate machine may be regarded as made up of two elements. One has constant induction, and is called the field magnet; the other is variable, and is called the armature. The field magnet may be excited by a direct current round it, or by an alternate current in the armature which is direct relatively to the field, because the armature changes position while the current changes its direction. As far as copper in the machine goes, it is cheaper to excite the fields by arranging the machine so as to have considerable armature reaction, and exciting by means of a condenser. Suppose when the field has its own coils the current density and weight of copper is the same in the field magnet and armature; if the field coils are removed and the condenser applied, the armature copper need not be doubled; it will carry the current at the same density as before, if the copper is increased in the proportion $\sqrt{2}:1$. The total power wasted is less than before; in fact, if the armature copper is not increased at all, the loss of power in the armature alone when the condenser is used is the same as that in the armamature and field-magnets together, with separate excitation. By the use of a condenser, cheapness, or higher efficiency, or a compromise of these can be obtained. The condenser itself is generally much cheaper than an exciter, and is, of course, very much more efficient. An alternate machine with a condenser follows practically the same laws as a shunt-wound dynamo, but it has only one copper circuit, and no commutator.

Perhaps enough has been said to show that condensers may have a large future. New possibilities are appearing every day, and there is no saying what combinations of capacity, self-induction, and resistance may be invented during the next few years.

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SUMMARY OF ELECTRICAL EVENTS FOR 1891.

JANUARY.

The action brought by the British Tanning Company, owning the Worms and Balé patents for tanning by electricity, against Mr. Groth, also the patentee of a similar process, came before Mr. Justice Romer, who invalidated the Worms and Balé patent on a point of law, and further decided that the Groth process was essentially different to that of MM. Worms and Balé (14th, 15th, 16th).

Institution of Electrical Engineers. Presidential Address, by Prof. Crookes, F.R.S., on "Electricity in Transitu: from Plenum to Vacuum" (15th).

Death of M. Emile Reynier.

Meeting of the National Telephone Company, proposed issue of further capital in the shape of debentures (£300,000 to £350,000) (21st).

Great snowstorm in the United States, which caused general havoc among the telegraph, telephone, and electric light wires, but especially so in the State and City of New York (25th).

Public appeals by University College and King's College for £50,000 apiece to meet the increasing demand for scientific and engineering education (26th).

Bill introduced into the United States Senate sanctioning the incorporation of a Pacific Cable Company with a capital of $5,000,000, and authorising the United States Treasury to grant the Company an annual subsidy of $200,000 for 15 years (26th).

Press visit to the Elmore Works at Hunslet, near Leeds (27th).

St. James and Pall Mall Company accept a licence from the Lane-Fox Electrical Company under their distribution patent No. 3,988 of 1878.

The residents of Peckham and East Dulwich petition the City and South London Railway Company to run a branch line from the Elephant and Castle through their districts.

A Special Committee appointed by the London County Council recommend that body to devote £23,000 during the current year to the furtherance of technical education, and to raise £130,000 per annum by a 1d. rate for the same purpose.

Dividends declared: Anglo-American Telegraph Company, 2⅞ per cent.

FEBRUARY.

Paper on "Electric Mining Machinery," read before the Institution of Civil Engineers, by Ll. B. and C. W. Atkinson (3rd).

Inauguration of the lighting of the streets of the City of London by electricity, the Lord Mayor laying the foundation stone of the first junction box just outside the Mansion House (3rd).

Publication by the Board of Trade of the resolutions to be submitted to the Electrical Standards Committee (10th).

The London County Council reject, by a majority of five, the recommendation of its Special Committee, that the sum of £23,000 should be set aside from the beer and spirit duties and devoted to the furtherance of technical education (10th).

Registration of the City of London Electric Lighting (Pioneer) Company, with a capital of £100,000 in £50 shares. Chairman, the Lord Mayor.

Tenders for the electric lighting of Dublin awarded to the Irish House-to-House Company and the Electrical Engineering Company of Ireland (11th).

The Glasgow Corporation invite tenders for the carrying out of their Provisional Orders (13th).

Publication of the awards made by the International Niagara Commission in connection with the projects sent to them for the utilisation of 125,000 h.p. at Niagara, and its distribution.

Re-commencement of the Deptford Supply (16th).

Cantor lectures on the "Electric Transmission of Power," by Mr. Gisbert Kapp.

Prof. Helmholtz decorated with the Grand Cross of the Legion of Honour by the French Government.

Some important transmission of power experiments at a pressure of 25,000 volts carried out at Oerlikon.

Publication of the report of the Special Committee appointed by the Salford Corporation to investigate the best mode of treating sewage. The electrical process favourably reported on.

The United States Senate propose to subsidise a cable connecting the United States with Hawaii (16th).

Meeting of the National Electric Light Association at Providence (R.I.) (17th, 18th, 19th). Interesting Paper, by Prof. Elihu Thomson, on "The Electric Arc and its Use in Lighting."

Paper on "Transformer Distribution," by Mr. J. Swinburne, read before the Institution of Electrical Engineers (19th).

The Mutual Telephone Company open their first exchange in Manchester (28th).

Dividends declared: India Rubber, Gutta Percha, and Telegraph Works Company, 10 per cent.; St. James and Pall Mall Electric Light Company, 5 per cent.; Liverpool Electric Supply Company, 3½ per cent.; Telegraph Construction and Maintenance Company, 20 per cent.

MARCH.

The United States Senate reject the proposal to subsidise a cable connecting the United States with Hawaii (3rd).

The Central London Railway Bill came before a Select Committee of the House of Commons (3rd).

Friday evening lecture at the Royal Institution on "Electromagnetic Repulsion," by Dr. J. A. Fleming (6th).

The laying of the London-Paris telephone cable commenced (9th).

Bristol Town Council agree to the report of their Electrical Committee, recommending the adoption of the alternate-current transformer system, the construction of a 10,000-light station, and the erection of 100 arc lamps for street lighting, at an estimated cost of £66,000 (10th).

The Central London Railway Bill reported to the House (11th).

Godalming Town Council decide to spend £7,000 on electric lighting.

Completion of the operation of laying the London-Paris telephone cable (14th).

Absorption of the South of England Telephone Company by the National Company (16th).

First word spoken through the London-Paris telephone line (17th).

Rejection of the City and South London Railway (Islington) Extension Bill by the House of Commons Select Committee (17th).

London County Council Overhead Wires Bill passes through Committee (18th).

The three stations of the Westminster Electric Supply Corporation come into operation.

Dividends declared: Direct Spanish Telegraph Company, 7 per cent.; Brighton and Hove Electric Light Company, 5 per cent.

APRIL.

The London-Paris telephone line opened to the public (1st).

Overhead wire raid by the New York municipal authorities (1st).

Paper on "The Cost of the Generation and Distribution of Electrical Energy," read before the Institution of Civil Engineers, by Mr. R. E. B. Crompton (7th).

Paper on "The Design of Multipolar Dynamos," read before the Institution of Electrical Engineers," by Mr. W B. Esson (9th).

Important Papers on "Electric and Magnetic Screening," read before the Royal Society by Sir William Thomson, also one on "The Measurement of Power given by any Electric Current to any Circuit," by Prof. Ayrton and Dr. Sumpner (9th).

The action brought against the London Electric Supply Corporation, by Messrs. Savory and Moore, to restrain them from erecting a transformer sub-station at the Grosvenor Gallery, directed by Mr. Justice Kekewich to stand over for three months, to enable the defendants to take steps to render the upper stories of their building fireproof (14th).

Petition for the prolongation of the Jablochkoff distribution patent (No. 1,996 of 1877) came on for hearing before the Judicial Committee of the Privy Council. Owing to the discovery that the cover and the face of the patent were dated differently, and that the patent was consequently invalidated by prior publication, the case was adjourned until May 20th, to enable petitioners to amend their petition (15th).

Formation of an association for the protection of the London telephone subscribers (15th).

London Overhead Wires Bill read a third time in the House of Commons (17th).

Central London Railway Bill read a third time in the House of Commons (20th).

Paper read before the Institution of Electrical Engineers, by Major P. Cardew, R.E., on "A Few Calculations on Electrical Shocks from Contact with High-pressure Conductors" (23rd).

Dividends declared: Oriental Telephone Company, 2¼ per cent.; Eastern Extension Australasia and China Telegraph Company, 7 per cent.; Indo-European Telegraph Company, 10 per cent.; Reuter's Telegram Company, 5 per cent.; Submarine Cables Trust, 6 per cent.

MAY.

Reductions, averaging over 50 per cent., in the cable rates to the colonies of Western Australia, South Australia, Victoria, New South Wales, and Tasmania (1st).

Inauguration of a Central Station supplying the Place Clichy district on the 5-wire system.

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Decision of the Conseil d'État in favour of the Anglo-American Telegraph Company in its action against the Paris-New York Cable Company (1st).

Successful public trial in Philadelphia of the Waddell-Entz alkaline traction accumulator (4th).

Paper read before the Institution of Electrical Engineers, by Dr. J. A. Fleming, on "Some Effects of Alternating-Current Flow in Circuits having Capacity and Self-Induction" (7th).

Paper read before the Institution of Electrical Engineers, by Mr. W. H. Preece, on "Some Points Connected with Mains for Electric Lighting" (7th).

Death of M. Edmond Becquerel (11th).

Petition for the prolongation and confirmation of the Jablochkoff distribution patent No. 1,996 of 1877, rejected by the Judicial Committee of the Privy Council (13th).

Paper read before the Old Students' Association, by Mr. E. B. Vignoles, on "Some Researches in Electro-magnetic Induction" (13th).

Paper read before the Institution of Electrical Engineers, by Mr. R. E. Crompton, on "The Most Economical Mode of Feeding a Low-Pressure Network" (14th).

Opening of the Frankfort Electrical Exhibition (16th).

Meeting of the American Institute of Electrical Engineers (19th, 20th, 21st).

National Telephone Company *v.* Muirhead. An action brought in the Scotch Courts to restrain defendant from supplying Ader and Berthon transmitters, and to obtain damages. Settlement arrived at (20th).

Announcement of awards in the Paris Municipality's electric meter competition. 1st prizes, *ex æquo*, Aron and Elihu Thomson meters; 2nd prizes, Frager and Marès meters (31st).

Opening of the Notting Hill Electric Lighting Company's station (31st).

Dividends declared: Great Northern Telegraph Company, 8·6 per cent.; Western and Brazilian Telegraph Company, 5 per cent.; West Coast of America Telegraph Company, 2½ per cent.; Consolidated Telephone Construction and Maintenance Company, 6 per cent.

JUNE.

Death of Mr. David Brooks, of Philadelphia (1st).

London Overhead Wires Bill, also Bill reviving Worms and Balé patent for electrical tanning, passed.

Paper on "Electrical Evaporation," read before the Royal Society, by Prof. W. Crookes; also two on "The Chemistry of the Secondary Cell," by Mr. G. H. Robertson and Prof. H. E. Armstrong (11th).

Celebration of the Centenary of Faraday's birth. Delivery of addresses at the Royal Institution on Faraday's electrical work, and on Faraday's chemical work, by Lord Rayleigh and Prof. Dewar respectively (11th and 26th).

Electrical disturbances at the Greenwich Observatory due to the City and South London Railway.

Deputation from the Associated Chambers of Commerce to the Board of Trade, urging the adoption of a complete system of electrical communication with lighthouses (12th).

Cambridge Town Council decide to erect a 10,000-light municipal electric lighting plant (16th).

Allison *v.* City and South London Railway. Action for damages and injunction to restrain Company from working their generating plant. Nuisance due to condensed steam, noise, and vibration proved. Company given two months to mitigate the same (16th, 17th, 18th).

Preamble of the Central London Railway Bill proved to the satisfaction of the House of Lords Select Committee (24th).

Death of William Edward Weber, at Göttingen (24th).

The streets of Carlow lighted by electricity (25th).

Trial run of the street lights in a portion of the City (25th).

Dividends declared: Anglo-Portuguese Telephone Company, 5 per cent.; West African Telegraph Company, 5 per cent.

JULY.

Royal Assent given to the London County Council's Overhead Wires Bill (3rd).

Conversazione of the Institution of Electrical Engineers (6th).

In the action brought in the United States by the Edison Electric Light Company against the United States Electric Lighting Company, decision given in favour of the Edison lamp patent (14th).

Successful experiments at Thames Ditton to show possibility of parallel running with Mordey alternators and Willans direct couple engines (14th).

Death of Mr. Willoughby Smith (16th).

Issue of a Board of Trade report showing that 58 Provisional Orders (34 to Local Authorities, 24 to Companies) have been granted.

Huddersfield Corporation accept Brush Company's tender for electric lighting station.

The action brought in the United States by Mr. Brush against the Electrical Accumulator Company terminated in a decision favourable to the claims of Mr. Brush (23rd).

Termination of the lighting of the streets of Barnet by means of glow lamps.

Dividends declared: National Telephone Company, 6 per cent.; Direct United States Cable Company, 3½ per cent.; Eastern Telegraph Company, 6½ per cent.; Edison-Swan United Electric Light Company, A shares, 7 per cent.; Globe Telegraph and Trust Company, 5¼ per cent.; Crompton and Co., 8 per cent.; Manchester Edison-Swan, 5 per cent.

AUGUST.

First half-yearly meeting since the opening of the line of the shareholders of the City and South London Railway. Chairman stated that 2,412,343 passengers had been carried, and 141,408 train-miles run. The receipts amounted to £19,688, and the expenses £15,520 (11th).

New cable laid between England and Germany (Bacton-Emden).

At the half-yearly meeting of the shareholders of the Liverpool Overhead Railway the definite adoption of electric traction and the conclusion of a contract with the Electric Construction Corporation to work the line for 3½d. per train mile (locomotive expenses) were announced (12th).

Resolution passed increasing the entrance and transfer fees of the Institution of Electrical Engineers (13th).

Sixty-first meeting of the British Association at Cardiff (19th).

Publication by the Birmingham Central Tramways Company of some satisfactory and important figures with regard to their accumulator cars.

Formation of the Electric Welding Company, with a capital of £460,000.

Death of Mr. Edward Gilbert, well-known telegraph engineer.

Death of the Postmaster-General (24th).

Successful preliminary trials of the Lauffen-Frankfort electric transmission of power plant.

Publication of the Report of the Board of Trade Electrical Standards Committee.

Death of Mr. John Louis Crossley (30th).

Dividends declared: Cuba Submarine Telegraph Company 8 per cent.

SEPTEMBER.

The Manchester Corporation decide to apply to the Local Government Board for permission to borrow £150,000 to carry out the proposed electric lighting scheme (3rd).

Opening of the Frankfort International Electrical Congress (7th).

Meeting of the National Electric Light Association at Montreal (7th, 10th).

Inauguration of the Brighton Municipal Central Station (14th).

Lengthy correspondence in *The Times* relating to the London telephone service; announcement by the Duke of Marlborough of a proposed competitive system by the New Telephone Company.

The South Staffordshire Tramways Company decide to work their system by electricity.

The Cork Consumers' Company decide to obtain an electric lighting Provisional Order.

Dividends declared: Brush Electrical Engineering 6 per cent. (half-year).

OCTOBER.

Decision of the Austrian Government to purchase the system of the Telephone Company of Austria.

Death at Florence of the Abbé Jean Caselli, inventor of the *pantelegraph*.

Close of the Frankfort Exhibition (19th).

Street Railway Convention at Pittsburgh (21st, 22nd, 23rd).

Opening of an electric tramway at Leeds 3½ miles long, overhead wires, Thomson-Houston motors, &c. (29th).

The Rothschilds place 175,000 francs at the disposal of MM. Hutin and Leblanc to carry out large scale experiments with their rotary field motor.

The American Patent Office decide against the Drawbaugh telephone patent applied for in July, 1880, on the ground that the invention in controversy was anticpated by Edison (25).

Dividends declared: Crompton Electric Supply Company of Australia, 7 per cent.

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NOVEMBER.

St. Pancras Vestry's central lighting station comes into operation (9th).

The Brecon Town Council decide to run an electric railway up the Beacons.

The Glasgow Town Council decide to take over the tramway system of the City in 1894 (12th).

The City of London Electric Lighting Company apply for an extension of one year in the time allowed for completing their street lighting contract (17th).

The Berliner microphone "interference" case decided. The patent applied for in June, 1877, issued November 17, 1891.

The Brighton Town Council refuse to purchase the goodwill of the Brighton and Hove Electric Light Company's undertaking for the sum of £7,000 as recommended by the Lighting Committee (19th).

Dividends declared: Woodhouse and Rawson United, 15 per cent.; Swan United Electric Light Company, 11 per cent.; Blackpool Electric Tramway 7½ per cent.

DECEMBER.

Prof. Ewing communicated to the Cavendish Physical Society the results of some experiments undertaken by him to determine whether or no the hysteresis losses in a transformer decrease as the load increases. He found no indication whatever of such a phenomenon (1st).

The Commissioners of Sewers refuse the application of the City of London Electric Lighting Company for an extension of time for carrying out the public lighting of the City (1st).

The London County Council refuse to lend the vestry of St. Pancras the £60,000 required by them to carry out their electric lighting scheme, and recommend them to borrow elsewhere (1st)

Important paper on "Secondary Batteries," read before the Society of Arts by Mr. G. H. Robertson (2nd).

The Nottingham Town Council empower their special committee to spend from £25,000 to £30,000 in lighting a central section of the borough by electricity.

The Board of Trade, in conjunction with the London County Council, the Corporation, and the Gas Companies, decide to appoint a committee to consider the question of a proper standard of light.

The National Telephone Company complain to the Leeds Corporation that their service is interfered with by the working of the Roundhay Park electric tramway. After hearing both sides the Corporation decide to let the two Companies settle the matter between them (7th).

The Richmond Town Council seal a contract with Messrs. Latimer, Clark, Muirhead, and Co. for the electric lighting of the borough (8th).

The London County Council approve a set of bye-laws drawn up in accordance with the London Overhead Wires Act, 1891 (8th).

The Electric Trade Section of the London Chamber of Commerce circularise members with regard to getting up a petition to the President of the Board of Trade against the decision of his department not to allow any overhead wires as a permanency (9th).

Prof. W. E. Ayrton, F.R.S., elected President of the Institution of Electrical Engineers for 1892. Institution premium awarded to Messrs. C. G. Lamb, E. W. Smith, and M. W. Woods; Paris Electrical Exhibition premium to Mr. J. Swinburne: Fahie premium to Mr. P. V. Luke (10th).

A Paper "On the Specification of Insulated Conductors for Electric Lighting and other purposes," read before the Institution of Electrical Engineers, by Mr. W. H. Preece (10th).

The City of London Electric Lighting Company commences the supply of current for private lighting (14th).

Bradford Town Council decide to extend municipal electric lighting area (15th).

Prof. Dewar communicated to the Royal Society the fact that he had discovered liquid oxygen at a temperature of −180° C. to be highly magnetic.

Mr. Justice Kekewich, at the suit of Messrs. Savory and Moore, grants an injunction against the London Electric Supply Corporation restraining them from using their Grosvenor Gallery premises as a transformer sub-station (18th).

Demonstration of the improved Benardos process of electric arc welding at Coombs Wood Works, Birmingham, by Messrs. Lloyd and Lloyd (21st).

Dividends declared: Electric Construction Corporation, 6 per cent.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December* 21, 1891.

Issue of a Fundamental Electric Railway Patent.—The United States Patent Office has again distinguished itself. Right upon the heels of the Berliner patent comes the issue of the final documents on the fundamental electric railway patent on an application dated 12 years ago. Investigation discloses a very interesting chapter in the history of the electric railroad. The patent itself covers broadly an electric railroad having a conducting circuit formed wholly or in part by the rails. The patentee is George F. Green, of Kalamazoo, Michigan. His work has been investigated with reference to its being used in some of the electric railway patent suits now in progress; and from what has been ascertained, it would appear that Mr. Green is the first American worker seriously to take hold of the problem since the early days when divers primary battery model roads were made. He is a poor workman, who has obtained his livelihood by making window sashes and blinds; his spare time being largely occupied by electrical experiments. For more than 20 years he has had the electric railway on his mind, and about 1875 built a little track a couple of hundred feet long, and of six or eight inch gauge, on which a model train was operated. The motive power was derived from a storage battery connected with the rails, the apparatus was operated by a motor of his own construction. This railway was displayed to his fellow-townsmen, and he made some effort to exploit it, but with no results; and about 1879 he built a model road on a larger scale, still operated by storage batteries, however; and on August 15th of that year he put in his application for a patent. He was so poor that he endeavoured to act as his own attorney, and consequently met with great obstacles in the Patent Office. The patent was rejected, even on appeal to the Commissioner, and was appealed from the Patent Office to the Circuit Court of the District of Columbia, the only tribunal that can order the issue of a patent after the decision of the Commissioner against it. He was in interference with Field, Hall, and others; but finally on December 8, the patent, after many vicissitudes and changes in the office, was issued in pursuance of an order of the Court. He had proposed to use a dynamo instead of storage batteries, but none was available. Although the patent in view of the many anticipations of primary battery days probably possesses no commercial importance, it forms a very interesting addition to the history of the electric railway, inasmuch as it establishes Mr. Green's priority in the general idea as against those of the various workers who entered the field about 1879. His work forms the connecting link between the electric roads proposed at various times from 1840 to 1860 and the electric traction of to-day, so that; historically speaking, the recognition of his rights by the Patent Office is of no small interest.

The Cuttriss Telephone Transmitter.—Apropos of the Berliner patent, it is interesting to note that Mr. Charles Cuttriss, of New York, has just patented a telephone transmitter, in which the variation of current is accomplished by the variation of tension on a spiral spring made of carbon. It is said to work admirably, and may prove a valuable addition to the list of telephonic apparatus, particularly in view of the Berliner claims.

Edison Stations in New York.—As an item of news in electric lighting, it may be mentioned that the Edison Illuminating Company has now connected all its stations in New York, forming a complete network extending from 59th Street to the Battery, and under complete control from the 26th Street Station, at which the pressure wires are concentrated. Up to two or three months ago the stations were independent, but the cross connections are now completed.

The Edison General Electrical Company.—Many rumours are afloat just now regarding possible changes in the management of the Edison General Electric Company. It is hard to say what truth there is in the various reports that have obtained credence in electrical circles and on Wall-street; but the feeling seems to be general that something is impending—what, will have to be determined after the annual meeting early in January. All the rumours suggest the withdrawal of Mr. Villard.

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From the forthcoming 1892 Edition of
The "Electrician" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.]

CENTRAL LIGHTING STATIONS OF THE UNITED KINGDOM.

LONDON.

IN OPERATION AND IN PROGRESS.

Name of Company.	Stations.	System.	Capacity in 8-c.p. lamps.		Area in sq. miles excl. of parks.	Price of B.T.U.
			Actual.	Ultimate.		d.
Chelsea Electricity Supply Company	Chelsea	Secondary Battery Sub-stations† with Continuous Current Transformers	30,000	90,000	1·13	8
City of London Electric Lighting Company	Bankside & Tower ..	Alternate Current Transformers, Brush and Thomson-Houston Arcs (515)	—	400,000	—	do.
Crystal Palace and District Electric Lighting Company	Crystal Palace and District	Continuous Current Transformers feeding Low Pressure Network	20,000	20,000	—	do.
Electricity Supply Corporation ...	Strand	Low Pressure	25,000	—	0·18	7¼
House to-House Electric Light Sup-Supply Company	West Brompton ...	Alternate Current Transformers (Lowrie-Hall)	25,000	100,000	0·77	8
Kensington and Knightsbridge Electric Light Company	Chapel-place, Brompton	Low Pressure, with Secondary Battery*	20,000	60,000	0·67	do.
Do. do. do.	Kensington Court...	Low Pressure, with Secondary Battery*	30,000	84,000	—	7¼
London Electric Supply Corporation	Deptford	Alternate Current Transformers (Ferranti)	90,000	290,000	3·37	do.
Metropolitan Electric Supply Company	Manchester-square..	Alternate Current Transformers (Parker)	30,000	—	4·6	do.
Do. do. do.	Paddington ..... *(in progress)*	Alternate Current Transformers (Kapp)	—	—	—	do.
Do. do. do.	Rathbone-place, Oxford-street	Alternate Current Transformers (Parker)	15,000	—	—	do.
Do. do. do.	Sardinia-street	Alternate Current Transformers (Westinghouse)	40,000	40,000	—	do.
Do. do. do.	Whitehall.....	Low Pressure, with Batteries†.....	10,000	—	—	do.
New Cadogan and Belgrave Electric Supply Company	Cadogan (Manor-street, Chelsea)	Three-wire system, with Secondary Batteries†	10,000	80,000	—	—
Notting Hill Electric Light Company	Notting Hill (Victoria Gardens)	Low Pressure with Secondary Batteries	—	—	0·69	—
St. James's and Pall Mall Electric Light Company	Carnaby-street ..... *(in progress)*	Three-wire system	60,000	—	0·24	7
Do. do. do.	St. James's	Three-wire system	40,000	—	—	do.
St. Pancras Vestry	Stanhope-street (No. 1 Station)	Three-wire system, with Secondary Batteries†	—	—	4·1‡	6
Westminster Electric Supply Corporation	Davies-street, W....	Low Pressure, with Secondary Batteries†	62,000	120,000	1·9	8
Do. do. do.	Eccleston-place, W.	Low Pressure, with Secondary Batteries†	30,000	120,000	—	do.
Do. do. do.	St. John's Wharf, Westminster	Low Pressure, with Secondary Batteries	45,000	60,000	—	do.

N.B.—In all the above districts the price of gas, January, 1892, is 3/1 per 1,000ft., excepting in the Crystal Palace district, where it is 2/6 per 1,000ft

* Crompton-Howell. † E.P.S. ‡ Including parks, etc.

PUBLIC COMPANIES WOUND UP IN 1891.

Amongst the public companies wound up during the past year are the following:—

Allchin, Linnell, and Co., Limited.
Alterion Company, Limited.
Automatic Standard Screw Company, Limited.
Cadogan Electric Light Company, Limited (reconstructed as the New Cadogan and Belgrave Electric Supply Company, Limited).
City of London Electric Lighting (Pioneer) Company, Limited (transferred to the City of London Electric Lighting Company, Limited).
Devon and Cornwall Electric Light and Power Company, Limited.
Electrical Engineering Corporation, Limited.
Electro-Metallurgical Company, Limited.
Excelsior Copper Company, Limited (reconstructed as the Leeds Copper Company, Limited).
General Zinc Recovery and Lighting Company, Limited.
India-Rubber Estates Company, Limited.
Institute of Medical Electricity, Limited.
Protean Battery Syndicate, Limited.
Simplex Electrical Syndicate, Limited.
South of England Telephone Company, Limited (amalgamated with the National Telephone Company, Limited).
Woodhouse and Rawson Electric Manufacturing Company, Limited (amalgamated with Woodhouse and Rawson United, Limited).
Woodhouse and Rawson Electric Supply Company of Great Britain Limited (amalgamated with Woodhouse and Rawson United, Limited).

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CENTRAL LIGHTING STATIONS OF THE UNITED KINGDOM.

PROVINCES.

IN OPERATION.

Station.	Name of Company or Proprietor.	System.	Capacity in 8-c.p.lamps.		Price of B.T.U.	Price of Gas per 1,000 ft.
			Actual.	Ultimate.		
					d.	
Birmingham	Birmingham Electric Supply Co....	Low Pressure	12,000	50,000	8	2/7
Blackpool	Blackpool Corporation	Street Lighting only	—	—		2/6
Bournemouth	Bournemouth and District Electric Supply Company	Alternate Current Transformers (Mordey)	7,500	—	8	3/6
Bradford	Bradford Corporation	Low Pressure with Secondary Batteries (Crompton-Howell)	15,000	—	5	2/3
Bridlington	Bridlington Local Board	Thomson-Houston Arcs (18)	—	—		4/
Brighton (2)	Brighton & Hove Electric Light Co.	Alternate Current Transformers (Lowrie-Hall)	—	—	10	2/9
	Brighton Corporation	Low Pressure with Secondary Batteries (E.P.S.)	9,120	—	7	
Lynmouth & Lynton	C. Geen	Alternate Current Transformers (Mordey)...	4,000	—		—
Chagford	Chagford and Devon Electric Light Company	(Water Power) Alternate Current Transformers ("Hedgehog"), Sub-Stations	—	—		—
Chatham	Chatham, Rochester and District Electric Light Company	Alternate Current Transformers (Ferranti)	—	—	5	2/1 & 2/6
Bath	City of Bath Electric Lighting and Engineering Company	Alternate Current Transformers (Mordey) Thomson-Houston Arcs (200 1,200 c.-p.)	12,000	30,000	8	2/8
Chelmsford	Crompton and Company	... ...	—	—		3/6–4/
Eastbourne	Eastbourne Electric Light Company	Alternate Current Transformers (Lowrie-Hall)	—	—	10	3/2
Exeter ...	Exeter Electric Light Company ...	Alternate Current Transformers (Mordey), Thomson-Houston Arcs (60 1,200 c.-p.)	6,000	19,000		3/2
Fareham...	Fareham Electric Light Company	Thomson-Houston Arcs (30) and Alternate Current Transformers	1,000	5,000	8	3/9
Galway ...	Galway Electric Light Company...	Low Pressure with Secondary Batteries ...	1,000	8,000	5	5/6
Hastings...	Hastings and St. Leonards Electric Light Company	High Pressure Direct Current; Arc and Incandescent (Brush)	—	—	8	3/4
Okehampton	H. Geen.....	Low Pressure	220	—		4/2
Derby ...	J. Davis and Son	Low Pressure with Secondary Batteries ...	500	2,000		2/1-2/6
Carlow ...	J. E. H. Gordon and Company ...	(Water Power) Alternate Current Transformers, feeding Low-Pressure Mains	2,000	—		6/8
Larne	Do. do.	Alternate Current Transformers, feeding Low-Pressure Mains	4,000	8,000		—
Keswick...	Keswick Electric Light Company	Alternate Current Transformers (Kapp) ...	—	—		3/3&4/
Ipswich ...	Laurence, Scott and Company.....	Low Pressure	1,000	—	8-6	2/10
Norwich...	Do. do.	Low Pressure	1,500	—	8-6	3/10
Liverpool (3)	Liverpool Electric Supply Company	Low Pressure	30,000	60,000	1/-4	3/-
Glasgow (2)	Mavor and Coulson	Alternate Current Transformers (Ferranti)	—	—	8	2/6
	do. do.	Low Pressure	—	—		
Leamington	Midland Elec. Light and Power Co.	Low Pressure	—	—	7-4	2/6–3/
Newcastle-on-Tyne (2)	Newcastle and District Electric Lighting Company	Alternate Current Transformers (Parsons)...	9,000	50,000	6	1/10
	Newcastle-on-Tyne Electric Supply Company	Alternate Current Transformers.....	—	—	4½	
Reading...	Reading Electric Supply Company	Thomson-Houston Arcs (90) and Alternate Current Transformers	1,000	20,000	8	3/
Buckingham	Rogers and Son.....	Low Pressure with Secondary Batteries ...	800	2,000		4/6
Cowpen ...	Sanderson and Company	Arcs and Incandescents	—	—		—
Sheffield...	Sheffield Telephone Exchange and Electric Light Company	Thomson-Houston Arcs (110) and Alternate Current Transformers (Mordey)	6,000	—		1/10–2/2
St. Austell	St. Austell Electric Light Company (J. E. Veale)	Low Pressure	—	—		5/
Taunton...	Taunton Electric Light Company	Thomson Houston Arcs (90) and Alternate Current Transformers	6,000	12,000		3/–3/6
Thetford...	Thetford Electric Light Company	Low Pressure with Secondary Batteries ...	1,000	2,500		5/
Waterford	Waterford Electric Supply Company	Thomson-Houston Arcs (70) and Alternate Current Transformers	1,000	—	8	5/6
Weybridge	Weybridge Electric Supply Company	Alternate Current Transformers	2,000	6,000	9	5/8
Woking ...	Woking Electric Light Company...	... ...	—	—		—

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CENTRAL LIGHTING STATIONS OF THE UNITED KINGDOM.

PROVINCES.

IN PROGRESS.

Station.	Name of Company or Proprietor.	System.	Capacity.	Price of B.T.U.	Price of Gas per 1,000ft.
Bacup.....	Bacup Corporation	Not selected.....	—	8	*3/7*
Bristol ...	Bristol Corporation	Alternate Current Transformers	—		*2/8–2/10*
*Cambridge	Cambridge Corporation	... ...	—		*2/10*
Dublin ...	Dublin Corporation	Arcs and Alternate Current Transformers.....	—		*3/6–4/*
*Glasgow	Glasgow Corporation	Three Wire System.....	50,000		*2/6*
Huddersfield	Huddersfield Corporation.....	... ...	—		*2/9*
*Bray	J. E. H. Gordon and Co.	(Water Power: Auxiliary Steam.) Alternate Current Transformers feeding Low Pressure mains	20,000		—
*Manchester	Manchester Corporation	Five Wire System	—		*2/6–3/*
Preston ...	National Electric Supply Company.....	Low Pressure	10,000		*2/7-2/9*
Northampton	Northampton Electric Light and Power Company	Secondary Batteries (Crompton-Howell)	—		*2/4*
Oxford ...	Oxford Electric Company, Ltd.	Secondary Batteries (E.P.S.) and Continuous Current Transformers	30,000	8	*2/6&3/*
*Portsmouth	Portsmouth Corporation	Three Wire System with Secondary Batteries...	—		*2/6*
Southampton	Southampton Electric Light and Power Company	Secondary Batteries (Crompton-Howell)	—		*2/10 3/4*
*Swansea	Swansea Municipal	Not selected.....	—		*3/4*
*Leeds ...	Yorkshire House to House	Alternate Current Transformers	—		*1/10*

* Those marked with an asterisk are only projected.

NEW PUBLIC COMPANIES OF 1891.

The following are the more important electrical and engineering limited liability companies registered during the past year, with their capital:—

Name of Company.	Capital.
Agence Dalziel	£60,000
Albert Electric Lighting Company	10,000
Albert Hoster	2,000
Alexander Mathieson and Sons	120,000
Anders, Elliot and Chetham-Strode.....	5,000
Arc Accumulator Company	1,000
Art Workshops	30,000
Aspinall's Enamel	125,000
Atéliers Hoster de St. Nicolas	2,000
Atlas Carbon Manufacturing Company	2,000
Aurora Electric Lighting and Distribution Company	25,000
Babcock and Wilcox	240,000
Benfield.....	50,000
Bicester Electricity Company	5,000
Birmingham Telegraph Factory	50,000
Blaikie Brothers	30,000
Bournemouth and District Electric Supply Company	50,000
Boy Messengers and Electric Call Company	200,000
British Electric Installation Contractors	20,000
British Electro-Chemical Agency.....	75,000
British Electrolytic Syndicate	100,000
British Hydraulic Foundry Company	200,000
Brown's Engine Company	15,000
Caledonian Telephone Company	50,000
Carbon Electric	20,000
Chloride Electrical Storage Syndicate.....	262 500
City of Bath Electric Lighting and Engineering Company	60,000
City of London Electric Lighting Company	800,000
City of London Electric Lighting (Pioneer) Company	100,000
City of Waterford Electric Supply Company.....	1,000
Collier Audible Telephone Syndicate	9,000
Concentric Seamless Steel Tube Company	20,000
Connelly Motor Company	70,000
County of London Electric Lighting Company	100,000
Crystal Palace District Electric Supply Company (name changed from the Electric Installation and Maintenance Company)...	100,000
Cuttriss, Wallis and Co.	10,000
Dermatine Company	55,000
Dobson and Barlow.....	750,000

Name of Company.	Capital.
East London Electric Supply Company	£1,000
Electrical Advertising Syndicate	10,000
Electrical Assets Purchase Company	1,000
Electrical Finance Corporation	100,000
Electrical Inventions Company.....	35,000
Electric Welding Company	460,000
Electrolytic Caustic Soda and Chlorine Trust	10,000
"Energy" Gas Electric Lighting and Power Company	20,000
"Engineering"	180,000
Epstein Electric Accumulator Company	101,000
European Sime-Edison Electrical Torpedo Company	201,000
Fibrate Syndicate	15,000
Foreign and Colonial Arc Accumulator Company	1,000
Fowler Insulator Syndicate	6,000
Froude-Hurrell Torpedo Company	10,000
Globe Electric Company.....	10,000
Gloucester Electricity Supply Company	100
Hampstead Electric Light and Power Company.....	1,000
Heath's.....	50,000
T. L. Hemming and Co.	5,000
Richard Hill and Co.	50,000
Home Telephone Company	500
Horton and Son.....	100,000
Richard S. Hughes	15,000
Improved Galvanising Company	75,000
International Electric Subway Company	25,000
International Electric Syndicate	12,000
International Inventions Corporation	100,000
Isle of Wight Electric Lighting Company	1,000
Italian Electrical Light and Power Company.....	60,000
P. R. Jackson and Co.	120,000
Jarrow Forge and Engineering Company	80,000
Johannesburg Lighting Company	150,000
Johnson, Matthey and Co.....	900,000
Keighley Electrical Engineering Company..... ...	10,000
Langness Copper Company	35,000
Law's Electrical Appliances Company.....	4,000
Leeds Copper Company.....	450,000
"Lightning"	3,000
London Electrical Tramways Company	150,000
Martiny	200,000
W. F. Mason	30,000
Mazapil Copper Company	50,000
Middlesborough Electricity Supply Company	100
Miller and Co.	100,000
Morecambe Electric Light and Power Company	15,000

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Moss Bay Hematite Iron and Steel Company	£308,196
Mountain's Wire Manufacturing Company	25,000
Thomas Moy	100,000
National Telegraph Works Company	5,000
R. S. Newall and Son	50,000
New Jersey Iron and Steel Company	680,000
New Motor Syndicate	5,000
Newmans	50,000
New York Belting and Packing Company	651,000
North-Eastern Telephone Company	4,600
Ogmore Valley Electric Light and Power Supply Company	10,000
Oxford Electric Company	100,000
Patent Electro-Magnetic Syndicate	25,000
Perfecta Steel Tube Company	30,000
Putney and Hammersmith Electric Light and Power Supply Company (name changed from the Stamford Hill and Tottenham Electric Light and Power Supply Company)	1,000
Queen Anne's Mansions, Lighting, and Heating Company	50,000
Railway and Works Contractors	102,620
Railway Electrical Fog Signal Syndicate	25,000
Read, Campbell and Co.	150,000
Refractory Ores Reduction Company	30,000
Rochdale Electricity Supply Company	100
Roper's Electrical Engineering Company	15,000
St. John, Hampstead, Electric Supply Company	1,000
Staffordshire Chemical Company	50,000
Star Tube Company(late Taunton and Hayward)	50,000
D. Steuart and Co.	100,000
Shropshire Electric Light and Power Company	25,000
South American Cable Company	500,000
Stoke-on-Trent Electricity Supply Company	100
Tayler Smith Electric Company	6,000
Townend Brothers	25,000
Tredlaw Engineering Foundry Company	10,000
Vulcan Engine Company	3,000
Waddington, Rath and Co.	25,000
Waddle Foundry Company	5,000
Walker (Henry) and Son	50,000
John Warner and Sons	40,000
Weybridge Electric Supply	15,000
Whessoe Foundry Company	50,000
William Melburn and Sons	20,000
Alex. Wilson and Company	20,000
Wyleys	60,000
Wyndham Electric Light Company	1,500

CORRESPONDENCE.

"INDUCTANCE" AND "HINDRANCE."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the recent Physical Society's discussion, I would suggest that if a name is really wanted for the companion to resistance in the impedance formula, the name proposed by me in *The Electrician* (August 17, 1888, p. 480) might be found suitable, namely, "hindrance."

To those who feel inclined to transfer the name "inductance" from inductance to hindrance (as above used) I would point out that although the matter is obscured and nonsensified in the irrational system of units, yet in my rational system inductance is a proper physical quantity in the same manner as conductance and permittance, depending upon a specific property of the material first (the inductivity, or the conductivity, or the permittivity), and upon the dimensions, &c., of the material or ethereal region considered. (*See* §§ 26 to 32 of "Electromagnetic Theory.")

Here 4π cropped up, of course. Now, regarding this, although (with the exception of an incidental remark) I should not have imagined it from what has appeared in this journal, yet I learnt from the *Electrical Review* lately that people were being exercised in their minds on the subject. This is as it should be. But there are three stages to salvation: first, you must be exercised in your mind until you come to recognise your sins; next, you must go on exercising your mind until you repent; lastly, you must keep on exercising your mind until you reform.

It is to be hoped, for the credit of electricians, that the third stage will be reached without needless postponement—to the next century, for instance. The longer the delay, after the second stage is passed, the worse will it be. The matter is of far greater intrinsic importance than any question of names.

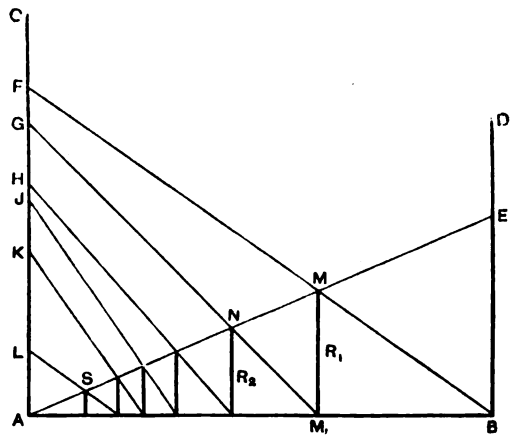
—Yours, &c., OLIVER HEAVISIDE.

Paignton, Devon, December 26, 1891.

THE COMBINED RESISTANCE OF CONDUCTORS IN PARALLEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to Fig. 2 in your article in *The Electrician* of the 18th inst., on "The Combined Resistance of Conductors in Parallel," I enclose a diagram on the principle shown applied to seven conductors instead of two only, as in your figure, and it certainly works out with extreme simplicity.



The construction of the diagram is as follows:—On any base of convenient length—A B—erect two perpendiculars—A C and B D. On B D set off a length—B E—to a suitable scale to represent the resistance of one of the parallel conductors; and on A C set off the lengths A L, A K, &c., representing all the other conductors. Taking the greatest of these—A F—and B E, draw the diagonals A E and F B and find the resultant resistance R_1, as in your diagram. From M_1 draw M_1 G, intersecting A E in N; and from N let fall the perpendicular R_2, the resultant of R_1 and A G. Proceeding thus, the point S is finally reached, which gives the total resistance of the whole seven conductors in parallel. For the purpose of ascertaining what extra conductor is required to bring the group down to a certain definite resistance, it is only necessary to take a point in A E at a vertical distance from A B equal to the desired total resistance, and to draw a straight line from the foot of the last resultant through this point till it cuts A C. The portion of A C thus marked off represents the resistance of the additional conductor needed.—I am, &c.,

December 24, 1891. W. S. BOULT.

WHAT IS ELECTRICITY?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your leading article of December 18th, under the attractive title, "Does Electricity Exist?" after referring to an illustration which represents a current of electricity passing through a voltameter as like to a stream of visitors passing through a turnstile, you say:—

> "When a hundred persons have passed, they can be collected, counted, and seen; they exist. When a coulomb has passed through a voltameter, where is it?"

This question seems to suggest that, in the respect referred to, the illustration fails; and that when a hundred coulombs have passed through a voltameter, they do not any longer exist, and cannot any longer be counted, like the people who have passed through a turnstile. But surely this is not so. A hundred coulombs passing through a voltameter all come out at the negative electrode; and an amperemeter, suitably placed in the circuit beyond that point, will count them all as they pass. Moreover, you may let them flow through a second voltameter, and they will do in it the same work as they did in the first; just as the people who pass through one turnstile may afterwards pass through a second. It would seem, then, that so far as this aspect of the question is concerned, the illustration of the turnstile and the people passing through it may be applied to the voltameter and the coulombs.

But my chief object in writing, at present, is to say a few words on the main subject of your article, the existence of

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electricity. If you will kindly allow me, I should like to take the opportunity of stating the question in the form under which it has, for some time, presented itself to my mind. There is a remarkable analogy between a current of electricity and two other familiar forms of energy, as regards the way in which they do work. When work is done by heat, the heat must fall from a higher to a lower temperature; when work is done by falling water, the water must fall from a higher to a lower level; and when work is done by a current of electricity, the electricity must fall from a higher to a lower potential. But if we compare heat and falling water, under another respect, we find a striking contrast between them. When heat does work, a certain portion of the heat disappears; and the work done is the equivalent of the heat that has ceased to exist. Hence we regard heat as a form of energy, because the heat itself is expended in doing the work. On the other hand, when work is done by falling water, no part of the water ceases to exist; and from this we infer that the energy, in this case, does not consist in the water itself, but in the fact that it exists at a higher level, under conditions which allow it to fall to a lower level.

The question then suggests itself, does the energy of the electric current, in this respect, resemble the energy of falling water, or does it resemble the energy of heat? The answer clearly is, that it does not resemble the energy of heat, but the energy of falling water. When a current of electricity passes through a glow lamp, and does work by keeping it alight, the quantity of electricity that comes out at one end is exactly the same as the quantity that goes in at the other; but it comes out at a lower potential, just as a stream of water, after turning a mill, comes out at a lower level. Electrical energy, then, consists in the existence of electricity at a higher potential, under conditions which allow it to fall to a lower potential.

These conceptions seem to me, in some degree, to clear the ground for approaching the question you have raised. But that question still remains: What is that thing which we measure in coulombs, and call quantity of electricity; which we can raise to a higher potential by the expenditure of work; and which, in falling again to a lower potential, gives us back work in return? Is it matter, or is it motion, or is it something different from both, and as yet unconceived?—Yours faithfully,

GERALD MOLLOY.

Catholic University, Dublin, December 22, 1891.

THE THEORY OF THE WIMSHURST MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The letter of Mr. Gray which appeared in your issue of December 11th contains a few points of theory which I think it may be useful to settle.

1. The uprights of the Wimshurst machine may be of metal (Bréguet pattern), and not of dry wood; in either case the two diametrical conductors are in metallic contact with each other; in multiple plate machines the brush-holders are in two halves. These organs can, therefore, only play an essentially passive part, which consists in putting the sectors to earth.

2. "When the number of sectors is reduced below a certain limit (say eight), the machine will not excite itself, but will work if a charge is imparted to it from an external source" (*see* Gray's "Electrical Influence Machines," p. 222). The machine can even be made without carriers, with bare glass plates. The theory of the Wimshurst machine and of its auto excitation are therefore totally different. The first is evidently peculiar to the Wimshurst machine, the second is common to all armature machines—Bennett, Toepler, Voss, Thomson, &c.

3. When a carrier in contact with a brush receives a negative charge by lateral induction, all the preceding sectors are positively electrified, and all those which follow it are in a neutral state. When several negative sectors have left the brush, their action is always less than that of the positive sectors, since: (i.) They are fewer in number; (ii.) Each individual charge is smaller than that of each individual positive sector. When all the sectors are electrified, lateral induction ceases to play an active part, owing to the predominating action of the sectors on the second plate, and to the symmetry of the opposite actions. This, at least, is what seems to me the most probable.

As to the question of priority raised by Mr. Gray, I will not return to it again. I have quoted the author's very words, and I therefore think it useless to press the matter further.—I am, Sir, &c.,

G. PELLISSIER.

Paris, December 22, 1891.

EFFECTS OF ALTERNATE-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the abstract of my Paper before the Physical Society on the 18th inst., printed in your last number, there is an error I should like to correct.

It is stated that in the experiment on the 100 k-w alternator, concentric cable, and 18 k-w transformer, the rise of pressure at the alternator terminals, observed on connecting the cable to them, was the same whether the transformer was loaded or unloaded. The facts are as follows:—The rise of pressure at the alternator terminals was—as far as could be observed—the same when the cable was connected to them, whether the transformer at the far end of the cable was in circuit or not, when the transformer secondary was open, or had only about a dozen 16 c.p. lamps as a load.—Yours, &c.,

Dec. 30, 1891. HAMILTON KILGOUR.

ROUNDHAY PARK ELECTRIC TRAMWAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 189 of your issue of December 25th, under the heading of the "Roundhay Electric Tramway," you state *apropos* of the accident upon my line during the fog on Monday, that it was about "an hour and a-half before the traffic could be resumed, the line being strewn with *débris*." A similar notice appeared in the *Daily Telegraph*, but I did not think it worthy of contradiction. Allow me, in the first place, to draw your attention to the fact that it would take a very large tram-car to furnish *débris* to block a tram line for an hour and a-half; and, secondly, to correct your statement by assuring you that within ten minutes after the accident both cars had run themselves into the car shed, no damage having been done, beyond smashing the front platforms of each car and breaking some panes of glass. The accident occurred entirely owing to the denseness of the fog and to the gross negligence of one driver running outside of his own schedule. Trusting you will give publicity to this correction,—I am, &c.,

December 24, 1891. W. S. GRAFF BAKER.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Offices not later than first post Thursday morning.*]

TENDERS INVITED.—The Manchester Corporation Gas Committee invite tenders for the supply of engines and boilers for the central electric light station in Dickinson-street. Conditions of contract and specifications may be obtained on application to Mr. C. Nickson, superintendent of the Gas Department, Town Hall; and tenders, addressed to the Chairman of the Gas Committee, are to be delivered at the Gas Offices, Town Hall, on or before January 20th. Further particulars will be found in our advertisement columns.

——— It will also be seen by our advertisement columns that the Chiswick Local Board are prepared to receive tenders for providing and fixing 10 alarm posts, and 16 calls to fireman, &c., and the necessary instruments in connection therewith, at the Fire Station in the High-road, Chiswick. Plans can be seen, and information obtained, of Mr. Arthur Ramsden, engineer and surveyor, Vestry Hall, Chiswick; and tenders are to be delivered to the Chairman, at a meeting of the Board to be held on January 6th, at 8 p.m., at the Vestry Hall.

TENDERS RECEIVED.—The Chatham, Rochester and District Electric Lighting Company (Limited) have received the following tenders for the erection of engine-room and other works at Chatham:—W. C. Snow, New Brompton, £1,300; W. Hocking, Strood, £1,240; G. Batchelor, Strood, £1,237.

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MESSRS. PATERSON AND COOPER.—This firm inform us they have been very busy during the whole of the past year, and in particular during the latter part. Shiplighting has contributed largely to the volume of business, and amongst the contracts on hand are those for the Allan line, the General Steam Navigation Company, and the Clyde Shipping Company. Dynamos during the past year have averaged a much larger size than previously. The arc lamp department has been busy, and large numbers have been sold for use. On alternating and constant current circuits a large number of important installations have been erected by Messrs. Paterson and Cooper, and the firm have still several important contracts on hand, including the lighting of the *Daily Chronicle* and *Lloyd's Newspaper* offices in Fleet-street, and the stores and wharf of Messrs. Nelson and Co., Lambeth.

MESSRS. J. H. HOLMES AND CO.—The *employés* of this firm held their fourth annual dinner last Saturday at the Crown Hotel, Newcastle-on-Tyne. The party numbered fifty, and after dinner an enjoyable programme was gone through. In response to the toast of "The Firm," Mr. J. H. Holmes gave a very interesting account of the evolution of the business of J. H. Holmes and Co., which was established in 1883, and made its first dynamo in 1885, and have recently heard that it is still working very well. The first ship lighted on the Tyne was lighted by Messrs. Holmes and Co. At the present time over 500 dynamos are at work, and the 624th machine is now being built. The toast of "The Electrical Engineers" was responded to by Mr. Broadbent, who gave a brief summary of the year's work, and remarked that during the year the firm had completed over 90 installations, and had fixed over 11,500 lamps; 95 dynamos had been erected for these installations. The year's output of dynamos had been 125.

EXETER ELECTRIC LIGHT COMPANY (LIMITED).—This Company have purchased the business and stock of the Exeter branch of the Italian Art Fittings Company, and have removed the latter to their new show rooms, 82, Fore-street, Exeter, where they intend to keep a large selection of electrical fittings.

BUSINESS FOR DISPOSAL.—There is for disposal in Russia an old-established electrical engineering business, brief particulars of which will be found in our advertising columns.

CHANGE OF ADDRESS.—Messrs. Barnes and Low, electrical engineers, notify us that on and after December 31, 1891, their business will be carried on at their new premises, No. 8, Exhibition-road, South Kensington.

MESSRS. GEORGE BOOR AND CO.—This firm, of 1 and 2, Artillery-lane, Bishopsgate-street, London, E.C., have been appointed by Messrs. Thompson and Robertson, of New York, sole agents for Europe and the Colonies for their new fibrous dry batteries.

DISASTROUS FIRE.—An extensive fire broke out on Christmas Day at the glass works of Messrs. Dan Rylands and Co. (Limited), the makers of the well-known glass-lined tubing, at Stairfoot, near Barnsley, by which damage was done to the amount of £60,000.

TRADE CATALOGUES.—We have received from Messrs. Dorman and Smith a catalogue and price list of their well-known electrical apparatus, including lamp holders, switches, cut-outs, switchboards, ceiling roses, brackets, and general electric light fittings.

——— Mr. Ronald A. Scott sends us a copy of his sheet price list for 1892, of the dynamos, motors, projectors, &c., made by him.

ALMANACS.—The Direct United States Cable Company send us a useful block almanac with space for memoranda, &c.

——— Messrs. Crompton and Co. send us a blotting pad and diary, similar to that issued last year, and which, with other similar pads, we have found very useful.

——— The Electrical Power Storage Company provide a most useful combination blotting pad, calendar, diary, and indexed memorandum, together with a full illustrated catalogue of their batteries and other goods.

——— Messrs. Fletcher and Co., of Warrington, send a block almanac with illustrations of their numerous gas appliances.

——— Messrs. W. H. Willcox and Co. send us a sheet date-remembrancer for 1892, each sheet showing illustrations of the very various manufactures of the firm.

BOOKS, &c., RECEIVED.

"Electricity Up to Date." By John B. Verity. (London: Frederick Warne and Co. 1s. 6d.)

"Yorkshire College, Leeds. Prospectus of Day Classes."

"How to Make Inventions." By E. P. Thompson. (New York: D. Van Nostrand. London Kegan, Paul and Co.)

"Decorative Electricity." By Mrs. J. E. H. Gordon. Second Edition. (London: Sampson Low and Co.)

"Annual Report of the Ballarat School of Mines." (Melbourne: The School of Mines.)

COMPANIES' MEETINGS & REPORTS.

Phonopore Syndicate (Limited).

The third annual general meeting of the Phonopore Syndicate (Limited), was held at Winchester House, E.C., on Monday last; Mr. E. H. Pollard presiding.

The SECRETARY (Mr. Percy Andreae) having read the notice convening the meeting,

The CHAIRMAN referred to the suggestion made in the report to the shareholders that, in view of certain important negotiotions now in progress, not only for the introduction of the phonopore telegraph on working lines, but also for the disposal of a portion of the Syndicate's patent rights, the meeting should be of a formal character only, and that all discussion of the Syndicate's affairs should be avoided. He was sure it would be in the interest of all the shareholders that, pending these negotiations, which he believed they would consider most satisfactory, no public allusion to their exact position and prospects should be made. This was the suggestion of the Committee, which the meeting could adopt or decline as it thought fit. The Committee had nothing to conceal, and if any shareholder wished for detailed information, and would call upon the Secretary, he would afford it. Reviewing the business of the past year, he pointed out that, in spite of the fact that the Committee had not been in a position to supply instruments for the actual working services of telegraph administrations until the middle of June, the phonopore telegraph apparatus had, since that time, been supplied to a very large number of the telegraph administrations of Governments and railways in all parts of the world. This was a fact for which the Committee took credit. But what was far more gratifying was that, after every possible practical test had been applied to the system that electrical ingenuity and science could devise, its successful employment had now been placed beyond a doubt. In substantiation of this statement he need only refer them to the report of Mr. Latimer Clark on the working of the phonopore telegraph in the service of the Midland and Great Northern Railway Companies—a report which, it was satisfactory to know, had since been fully confirmed by the official testimony of these and other telegraph administrations which were employing the phonopore telegraph. He concluded by moving the adoption of the report and the acceptance of the accounts.

Mr. G. N. DAWE seconded the proposal, and asked the Chairman what was the cause of the delay in receiving the instruments for commercial use.

The CHAIRMAN said that at the time of the last report they expected that their order for the manufacture of the instruments would be executed within six weeks from the date of its issue. The order was given in February, but from various causes the instruments were not delivered until June.

Mr. MOCATTA said it was important also that they should be most careful at the present moment, because they knew that whatever amount of money was required for what was now becoming a valuable commercial undertaking would be found, as the Company was in the hands of men who had the true interests of the shareholders at heart.

The motion that the report and accounts submitted by the Committee be adopted and passed was then put and carried unanimously.

Mr. Browne and Mr. E. H. Pollard, the retiring Directors, were then re-elected, as were also Messrs. Boyce and Ramsay, the accountants.

The CHAIRMAN said he presumed he might take it that it was their wish that the suggestion of the Committee—to confine the discussion at that meeting to mere matters of form, and to take the adjournment—should be complied with. He therefore proposed that the meeting be adjourned until April 22, 1892, unless the Committee should find it expedient to summon the shareholders together at an earlier date.

The motion for the adjournment was then put and carried; and the CHAIRMAN and Mr. BROWNE having briefly returned thanks for their re-election, the meeting terminated with the usual vote of thanks.

Elmore's Patent Copper Depositing Company (Limited).

The second annual ordinary general meeting of the shareholders of this Company was held on Wednesday at the Cannon-street Hotel, under the presidency of Mr. J. Jepson Atkinson.

The SECRETARY (Mr. J. Shurmer) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, there is an old saying, "Good wine needs no bush," and I think that after the report we have been able to send you, you will not think it necessary for me to address you at any great length. You will see by the report that all the preliminary difficulties have been entirely overcome, and that we are now ready to go forward and earn money for you, and pay you handsome dividends. When we double, treble, and even quadruple our present plant, which we shall in due course have to do, those dividends will be so increased that I honestly believe you will have a chance of getting returns of cent. per cent. upon your investment in the capital of the Company. You will be glad to hear that our difficulty is not to take orders, but to know what orders to refuse out of the great number on offer. As you know, there is a French Elmore Company formed to work the process in France, and last week I had the honour of being invited to see their work. These works are now in operation, and though designed for an output of 90 tons a week, already their manager reports that he can sell double their proposed output. From these remarks, and the figures which Mr. Elmore will give you, you will see there is not

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the slightest question about our getting a sufficiency of orders. I have no dividend to declare, but I can state to you, gentlemen, that we are to-day actually earning a considerable one—there is £500 profit in our tanks for this week—and I myself expect that before very long we shall be able to send each of you a nice little cheque as the result of what we are earning. I should like to say a few words about our investment in land referred to in the report. As you are aware, we are not a Land Company, and in the ordinary course we should only have bought sufficient land for our own immediate requirements; but being myself an adjacent landowner, and knowing well its value in the neighbourhood of the rising town of Leeds, and finding that we should have to pay something like £2,000 an acre for any extension of our works, and then be exposed later on, if we wished to further increase them, to still larger demands, I strongly urged the Board to make the purchase of the whole estate at Haigh Park. This the Company did not see its way to do at the time, and Mr. William Elmore very pluckily stepped in and bought the property. Later on, when the land had increased in value, and we saw the bargain that Mr. Elmore had, we readily accepted his generous offer to let the Company take over the purchase at the original price. Since that time, as we have mentioned, the value of the land has greatly increased, and I have received a letter from a gentleman who is acknowledged in Leeds to be the greatest authority on the value of land in that neighbourhood, in which he says, "I think the Company have done well to acquire the estate, and especially if they can afford to wait awhile before realising." In addition to this and the other advantages set out in the report, the Midland Railway Company have not only agreed to spend a considerable sum in improving the means of communication with the estate, but have also arranged, later on, to build a passenger station contiguous to our property. In justice to Mr. Elmore I must say that he has worked like a Trojan, and, even if he has been slow in getting our Company to its present prosperous position, he has, nevertheless, given one of the greatest possible proofs of his zeal for the Company, and his interest therein, by giving up his purchase precisely on the same terms as he had procured it. If he had been a stranger, there would have been nothing wrong in his asking £25,000 profit on the price, and then we should have had a bargain. In fact, if at the end of a year or two the Company do not find that they have made a splended bargain, I shall be glad to take it off their hands. I think, therefore, that our thanks are very much due to Mr Elmore for the excellent position he has put us into in that respect; and I have no doubt that, before we part, you will favour him with a vote of thanks instead of a cheque for the profit he might otherwise have made. Three members of the Board retire. Sir John Morris is not allowed by his physician to offer himself for re-election, but possibly he may be able to join us again later on. With regard to the other two members, Mr. Carson and myself, I may say that Mr. Carson, from his knowledge as a Director of the Cape Copper Company, of which he was originally the manager, has been of great assistance, and is one of the four largest holders of our shares. I myself have every confidence in the great value of this invention, and I have had ever since it was only an idea in the mind of the inventor. I hold over 8,000 shares in the Company, and have upwards of £40,000 in the various Elmore Companies, and have never sold a single share, even when they were at £8 each, which figure, I believe, they will soon be at again. On the contrary, I have been steadily increasing my holding. In fact, I may say the Directors of your Company are by far the largest holders in the Company, holding I believe nearly a third of the issued capital. Mr. Elmore has addressed a statement to the Directors, dated December 28, 1891, in which he says, among many other things, that he confirms his report of the 30th November last, and the gratifying results he was then able to foreshadow, and begs to state that their experience since more than bears out his figures. He concludes his report as follows:—"In this report of to-day I have confined myself to what has actually been done and proved, and I consider it unnecessary to refer to the fact that our process is equally applicable to the deposition of other metals, and the manufacture of heavy ordnance, of a quality hitherto unknown, and I think you will find, as in the past, that every statement ever made by me as to the various applications of the process will be as fully borne out as those regarding the turn out of copper tubes and such like articles; this I have been able to prove to you to-day. In conclusion, the Chairman said I now beg to move—

"That the report and statement of accounts for the year ending June 30th last be passed and adopted."

General FIFE (a shareholder) seconded the motion.

A discussion followed, in which Messrs. Bogle, Pilcher, and other gentlemen took part, and

Mr. ELMORE, in reply, said that the accounts were made up to the 30th June. At that time they were making very little copper from their tanks, and consequently there was no profit, or very little profit, shown in the statement of accounts. The profits had all been made since. At the present time they were turning out a large quantity of copper tubes. With respect to the laminated tubes, at the commencement of their operations they started, unfortunately, with a very defective engine which, however, was made by one of the best engineering firms in the world, or supposed to be one of the best. It gave them considerable trouble, and was constantly breaking down. This was the cause of the laminated tubes, a few of which were sent out in the early period of the Company. The process was essentially a continuous one, and the stoppage of an engine for any time would cause a film of dust to settle on the solution in such a way as to cause a lamination. This, however, was a thing of the past, and never happened now. In the last six weeks they had sent out a very large quantity of tubes to some of the best firms in the world, who had not only expressed their high satisfaction with the quality of the tubes, but had repeated their orders. One Manchester firm had promised them an order for 1,000 tubes of 22 in. diameter, to be delivered over the next year. They had been exceedingly anxious not to send out any tubes for steam purposes lately, until, in fact, they were quite certain of their ground; and for this purpose he desired a little time ago that official tests should be made by the engineers and experts of the Board of Trade, the Admiralty, and Lloyds. Those bodies had consented to make these tests.

Mr. PILCHER asked if they would guarantee the tubes they now sent out, and

Mr. ELMORE replied that they would do so with pleasure. By the operation of the process, if the current was continuous and the rotation of the mandril in the tank was continuous the tubes must be of absolutely uniform strength throughout, and could not be laminated. There was no difficulty whatever in keeping the current continuous. These difficulties sometimes came as blessings in disguise. The very fact of their making a laminated tube actually caused the taking out of certain patents by the Company for the manufacture of sheet copper, which they were now making of magnificent quality. It was done automatically. It was not necessary to put the sheets through any rolling processs whatever, and the stuff was never touched by hand. They could, if necessary, sell it at a price decidedly below the ordinary market quotation. There was no doubt at all that if coppersmiths could procure a tube which would stand three times the pressure of another tube, they would be satisfied to give, at any rate, a little higher price; nevertheless, if necessary, they could sell it at less than the market price. With regard to the question as to their making a profit of £174,000 a year, he had never made such a statement, and he did not know to what it referred. Their working of 20 tons a week had only just commenced—within the last fortnight. He hoped that they would be able to get a considerable increase to their plant, and, in fact, be able to double it within three months.

The resolution was carried unanimously; and resolutions were afterwards passed re-electing the retiring Directors, Mr. Atkinson and Mr. Carson, and the auditors, Messrs. Price, Waterhouse, and Co.

Cordial votes of thanks to Mr. Elmore and his staff and to the Chairman and Directors were passed, and were acknowledged by Mr. Elmore and the Chairman; and the proceedings then terminated.

Elmore's Wire Manufacturing Company (Limited).

The first annual ordinary general meeting of the shareholders of the above Company was held on Wednesday last, at the Cannon-street Hotel; Mr. J. Jepson Atkinson presiding.

The SECRETARY (Mr. J. Shurmer) read the notice convening the meeting; and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, the report speaks for itself, and is so exceedingly simple that in addressing you I can have very little to say. What will strike you first is that a Company calling itself a wire manufacturing Company should propose to you, its shareholders, after you have subscribed your capital, not even to put down plant to draw wire at all. This admits of an easy explanation. Gentlemen connected with the wire-drawing trade, and having large capital invested in drawing plant, approached us some time previous to your last general meeting, and having thoroughly tested the quality of the copper to be produced by us, offered to take our entire output at a price which, while satisfying us, did not interfere with their own business of drawing. Your Directors considered that this arrangement was better than entering into competition with the whole trade. This was explained to you at the last general meeting. Since then we have ascertained the fact that by depositing our large copper tube up to about a quarter of an inch and over, and then cutting them up into a wide spiral of, say, two inches, which can be done very easily indeed, we have a form of copper-ribbon or tape used for electric lighting and transmission of power. While the demand for this copper-tape exceeds our entire output the price is much in excess of the best price we could obtain for wire spirals such as the wire-drawers would have taken, so that even before the whole of our works are complete we shall have a better market for our produce than was contemplated when the prospectus was issued. The electric lighting of a town like Leeds would keep us busy for a length of time, and I am informed that for the electric lighting of London alone over 100,000 tons of this kind of strip will be used. A second very simple invention is likely to form an important source of revenue to us. It was found that by exposing the mandrel to the oxidizing action of the atmosphere for a few minutes, when a certain thickness of copper was deposited upon it, and then continuing the operation till a similar thickness of copper was deposited, and by a continual repetition of this process, a series of tubes could be formed entirely separate and distinct from one another. One cut down the length of these superimposed tubes gave, when opened out, a number of beautifully burnished sheets of perfectly even surface and thickness, and equal in every way to those known in the trade as planished sheet. These, of the size furnished by us, cannot be procured at the present time in the market, and consequently they will command a high price. All I have to say in addition is that this meeting was put off to the last minute in the hope that I should be able to announce to you that the 35-ton plant was at work; the fog and the Christmas holidays have prevented it, but there is steam in our boilers, and very little more to do at the plant, and we hope within three weeks or so to be at work. Our business being a mere repetition of the same process over and over again, and the fact that we have no customers to seek, or market to create, make it evident that as soon as ever we get a start our dividend-earning will commence. Some of you have seen the works, and know from what you have seen that a great deal has been done, and the drawing, accompanying the report, will give those who have not been down an idea of the size of our premises, which, I am told, comprise the largest shed in Yorkshire. He concluded by moving the adoption of the report and accounts.

Mr. E. J. CARSON seconded the motion.

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The MANAGING DIRECTOR (Mr. Wm. Elmore) explained that owing to the delay of the various contractors responsible for providing the necessary plant, &c., in fulfilling their contracts, the Company had not been able up to date, as had been expected, to proceed with its operations; but he expected that within a fortnight from this time it would be in a position to produce about 35 tons of copper wire per week, which could be readily increased, with little additional expenditure, to 70 tons per week.

The motion was agreed to.

Mr. BLOOMER proposed and Mr. WHITE seconded the re-appointment of the auditors, Messrs. Deloitte, Dever, Griffiths, and Co.

The resolution was carried unanimously.

On the motion of Mr. GUARRACEM, seconded by a SHAREHOLDER, a vote of thanks was unanimously accorded to Mr. Elmore for his services to the Company.

Mr. ELMORE, in expressing his acknowledgments, assured the shareholders that no effort on his part would be spared to make the business in which the Company had embarked a financial success.

A vote of thanks having been passed to the Chairman and Directors, the proceedings terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

ELSNER AND CO. (LIMITED).—This Company was registered on December 22, 1891, with a capital of £12,000, in £50 shares, by Messrs. Foss and Ledsam, 3, Abchurch-lane, London, E.C. The objects are to acquire and carry on the business of engineers in all its branches, and manufacturers of machinery, plant, and goods of all descriptions, and to act as merchants, contractors, and commission agents for the purchase and sale of all kinds of plant, machinery, chemicals, and other processes and merchandise. Registered office: 80, Lombard-street, London, E.C.

HULL TRAMWAYS COMPANY (LIMITED).—This Company was registered on December 23, 1891, with a capital of £25,000, divided into 2,500 Founders' shares of £1 each, and 2,250 ordinary shares of £10 each, by Walter Webb and Co., of 23, Queen Victoria-street, London, E.C. The objects are to purchase or otherwise acquire, or take a lease of, all or parts of the existing street tramways at or in the neighbourhood of Kingston-upon-Hull, and to equip, maintain, and work with horse, steam, or other mechanical power, or electricity, the tramways belonging to or leased by the Company.

KEIGHLEY ELECTRICAL ENGINEERING COMPANY (LIMITED).—This Company was registered on December 24, 1891, with a capital of £10,000, in £1 shares, by Ullathorne, Currey, and Villiers, 1, Field-court, Gray's Inn, W.C. The objects are to carry on in England and elsewhere the business of electrical engineers and of electric lighting, and to produce and supply electricity or electrical currents and force; and also to supply whole or in part, by means of electricity or electrical currents or force, light, heat, motive-power or force, or telegraphic, telephonic, or other means of communication or illumination, and to acquire the business of C. J. Garnett, now carried on by him at South-street, Keighley, and to carry on the same. Registered without Articles of Association.

LIVERPOOL METAL AND HARDWARE COMPANY (LIMITED).—This Company was registered on December 22, 1891, with a capital of £12,000, in £10 shares, by J. and R. Gole, 4, Lime-street, London, E.C. The objects are to acquire the undertaking of Peter Connor, McIntyre, and Co. (Limited), carried on at Hanover-street, Liverpool, and elsewhere; to carry on the business of copper, brass, iron, lead, tin, zinc, spelter and general metal and hardware merchants, and also that of mechanical and electrical engineers, machinists, smiths, woodworkers, &c.

MINERAL SYNDICATE OF SMYRNA (LIMITED).—This Company was registered on December 24, 1891, with a capital of £15,000, in £5 shares, by Batten, Proffitt, and Scott, 32, Great George-street, Westminster, London, S.W. The objects are to carry on and conduct in England, Turkey, and elsewhere the business of manufacturers of emery flux, ferro aluminium, copper, and aluminium, ironmasters, colliery proprietors, chemical manufacturers, engineers, smelters, steel makers, and iron founders, and to construct, carry out, maintain, and work (*inter alia*) gas works, hydraulic works, electric light, heat, and power supply works, chemical works, &c.

AUTOMATIC STANDARD SCREW COMPANY (LIMITED).—A resolution was passed at a meeting held on November 26th, and confirmed at a meeting held on December 14th, that the Company be voluntarily wound up, and that Mr. H. L. Roth, Lightcliffe, be liquidator.

BIRMINGHAM TELEGRAPH FACTORY (LIMITED).—An agreement made November 25, 1890 (and filed on December 24, 1891), between Fowler, Lancaster, and Co. (Limited), electrical engineers (herein called the vendors) of the one part, and A. F. Hoggins (called the purchaser), agent on behalf of the above-named Company, then in formation, of the other part, states that whereas the vendors have for some time past carried on the business of electric telegraph instruments, bell and battery manufacturers, in connection with, or as a department of, their business of general electrical engineers, manufacturers, and contractors in their factory, Albert Works, Graham-street, Birmingham, it is therefore agreed that the vendors shall sell and the purchaser shall buy (1) the goodwill of the said department of their business of electric telegraph and telephone and other electric signalling apparatus or instruments, bell, and battery manufacturers; (2) all the stock-in-trade connected with such business; (3) all unfinished contracts, agreements, rights, and privileges to which the vendors are or may be entitled in relation to the said department; and (4) all patents or licenses connected therewith, provided that the purchaser shall not be compelled to take over with the conveyance hereby contemplated all rights and liabilities under the agreement with Mason and Avery, being a licence for the manufacture of Snelgrove's electric bells. The consideration for the said sale shall be £5,000, to be satisfied by the payment of £1,000 in cash, and by the allotment of 400 fully paid-up shares in the Company of £10 each, to be numbered 781 to 1,180 inclusive. An agreement dated December 15, 1891 (also filed on December 24th) between Fowler Lancaster and Company (Limited) of the one part, A. F. Hoggins of the second part, and the Birmingham Telegraph Factory (Limited), of the third part, states that it is mutually agreed that the above agreement is hereby adopted by the Company, and shall be binding on the Company, and the said A. F. Hoggins shall from henceforth be discharged from all liabilities under or in respect of the said agreement The above named Company was registered on December 31, 1890, with a capital of £50,000, in £10 shares, to carry on the business of telegraph and telephone engineers and contractors, and manufacturers of telegraph appliances, telephone appliances, wires, cables, insulated materials, and other apparatus, and it is intended to acquire the business carried on by Joseph Slater Lewis, telegraph engineer and manufacturer, at Birmingham. The statutory return made up to May 6, 1891, and filed on the 14th following, shows that only seven shares had been taken up, on which nothing had been called or paid. Registered office: Birmingham Telegraph Factory, Graham-street, Birmingham.

ELECTRIC INSTALLATION AND MAINTENANCE COMPANY (LIMITED).—At an extraordinary general meeting of the members of the above-named Company, duly convened, and held at the registered offices, 4, Great Winchester-street, London, E.C., on December 3, 1891, the following special resolutions (see *The Electrician*, December 4th, p. 133) were duly passed, and at a subsequent extraordinary general meeting of the members of the said Company, also duly convened and held at the same place, on December 19, 1891, the following special resolutions were duly confirmed: —(1) "That the name of the Company be changed from the 'Electric Installation and Maintenance Company (Limited)' to the 'Crystal Palace District Electric Supply Company (Limited)';" (2) "That each of the existing £10 shares be divided into ten £1 shares"; (3) "That the existing Articles of Association of the Company be cancelled, and that the Articles of Association, which have been produced to the meeting and signed by the Chairman, be the regulations of the Company, and be registered accordingly." The new Articles of Association of the above-named Company, which were registered on December 23, 1891, with the foregoing show that the capital is now £100,000, divided into 100,000 shares of £1 each. The number of Directors shall not be less than three nor more than seven, but the continuing Directors may act notwithstanding any number of vacancies. The present Directors, viz., Colonel Lewis Vivian Loyd, D.L., Joseph Pyke, Esq., Samuel Green, Esq., and Robert M. Meyer, Esq., shall hold office until the first ordinary general meeting in 1894. Qualification, shares to the nominal amount of £250. Remuneration, £1,000 per annum (in addition to their travelling expenses, and also in addition to the salary of a managing Director or Directors, if any), and in any year when a dividend of 6 per cent has been earned for the ordinary shareholders, the Directors shall be entitled by way of extra remuneration to a further sum of £5 per cent. per annum on all additional profits, the above to be divisible among the Directors as they themselves determine. The above Company was registered on June 30, 1883, under the title of the "Electric Construction and Maintenance Company (Limited)," with a capital of £100,000, in £10 shares. The annual returns for the years 1884, 1885, 1886, 1887, and 1888, which were all filed on June 27, 1889, show that only seven shares had been taken up, and nothing had been called or paid. The return for 1889, however, shows that 82 shares had been taken up, but nothing had been called or paid. The additional 75 shares were taken by H. G. Wright, Esq., John Irving Courtenay, Esq., and Sir Henry C. Mance, who took 25 shares each. In November, 1889, the name of the Company was changed to "The Electric Installation and Maintenance Company (Limited)," and the license of the Board of Trade for such change granted December 9, 1889. The return for 1890, filed the 27th February last, shows that 626 shares have been taken up, £5 per share called upon 487 of these, and £2,260 paid, leaving £175 in arrears. £1,390 is considered as paid on 139 shares, and, in addition to the shares issued, agreements had been entered into for appropriating under Provisional Orders, obtained or applied for, 5,724 shares of £10 each fully paid. The shareholders include the well-known names of J. Irving Courtenay, Esq. (25 shares), Sir H. C. Mance (25), J. B. Verity, Esq. (50), Sir Daniel Cooper, Bart., G.C.M.G. (50), James Pender, Esq. (50), and Sir C. D. Fox (50), and the Electric Construction Corporation (Limited) hold the 139 fully-paid shares. Present registered office: 4, Great Winchester-street, London, E.C.

LIVERPOOL ELECTRIC SUPPLY COMPANY (LIMITED).—The following was filed on December 24, 1891:—At extraordinary general meetings of the Liverpool Electric Supply Company (Limited), duly convened and held respectively on December 7 and 23, 1891, the subjoined special resolutions were duly passed and confirmed: (1.) That in accordance with Section 9 of the Liverpool Electric Lighting Order, 1889, further share capital of the Company of the nominal value of £40,000 be, and the same is hereby, appropriated as a separate capital for the purpose of the undertaking thereby authorised in respect of the district comprised in schedule A of the said Order. (2.) That in accordance with Section C of the Liverpool Electric Lighting Order, 1891, share capital of the Company of the nominal value of £20,000 be, and the same is hereby, appropriated as a separate capital for the purpose of the undertaking authorised by that Order. (3.) That the regulations contained in the printed document submitted to the meeting, and for the purpose of identification subscribed by the Chairman thereof, be, and the same is hereby approved, and that such regula-

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tions be, and they are hereby, adopted as the regulations of the Company, to the exclusion of all the existing regulations thereof. The new Articles of Association, which were filed with the above notice, state that the number of Directors shall not be less than three nor more than nine, the present Directors being J. S. H. Banner, A. H. Holme, S. H. Holme, Sir David Radcliffe, T. von Sobbé, J. C. Vaudrey, and Domingo de Ybarrondo. Qualification, £500. Remuneration as determined by the Company in general meeting. The above Company was registered on January 10, 1883, with a capital of £10,000, in £5 shares, and in July, 1885, the capital of the Company was raised to £200,000 by the addition thereto of 38,000 shares of £5 each. The last return, made up to March 10, 1891, and filed on April 7, 1891, shows that all the shares have been taken up, and upon 10,000 the full amount has been called, while upon the remainder £3 per share has been called, resulting in the payment of £139,400. 10s., leaving £599. 10s. in arrears. Registered office: 15, Highfield-street, Liverpool.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts of this Company for the week ended December 27th amounted to £871, as against £785 for the corresponding period of last year, an increase of £86. Aggregate receipts for half-year to date, £19,221.

QUEEN ANNE'S MANSIONS LIGHTING AND HEATING COMPANY (LIMITED).—Notice is given that the coupons due January 1, 1892, on the debentures of the above Company will be paid at the National Provincial Bank of England (Limited), 112, Bishopsgate-street Within, on and after to-day. Coupons must be lodged three clear days for examination.

MANITOBA ELECTRIC AND GAS LIGHT COMPANY (LIMITED).—Messrs. Robert A. McLean and Co. announce that the coupons due January 1st on the Six per Cent. First Mortgage Bonds will be paid by them on and after to-day.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Dec. 22.	Price Wednesday, Dec. 30.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Dec. 30. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/6	Anglo-American	49½ 50½	50½ 51½	5 1 11	Jan., Apr., July, Oct	51	50½
£2,849,510	Stock	25/0	Do. Preferred	87½ 88½	88 89	5 18 0	" "	88½	87½
£2,849,510	Stock	5/0	Do. Deferred	12¾ 13¼	14 14½	..	" "	13½	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July	..	..
130,000	£10	3/0	Brazilian Submarine xd	11 11½	10¾ 11¼	7 2 3	Mar., June, Oct., Dec.	11⅜	..
£68,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104 108	104 108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock xd	145 148	149 151	4 12 9	April and October	..	..
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½ 3¾	3½ 3⅝	6 18 8	April and October	..	..
6,000	5	10%	Do. Preference 10%	9¼ 10¼	9¼ 10¼	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10⅜ 11⅛	10⅜ 11⅛	6 6 2	Jan., Apr., July, Oct	11	10⅜
400,000	10	2/6	Eastern	14 14½	13⅜ 14⅛	4 12 0	" "	11½	14
70,000	10	6%	Do. 6 per Cent. Preference	14½ 15½	14½ 15⅜	3 16 2	" "	15⅜	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106 109	106 109	3 13 5	May and November	108½	107
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	108 111	4 10 1	February & August	109	..
250,000	10	2/6	Eastern Extension	15 15½	15 15½	4 12 7	Jan., Apr., July, Oct.	15 5/16	..
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107 110	107 110	3 12 9	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104 107	104 107	4 13 6	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	103 106	103 106	4 14 4	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99 102	92 102	3 18 5	Febuary and Au ust	100½	..
180,227	10	2 0	Globe Telegraph and Trust	9½ 10	9¾ 10½	5 6 1	Jan., Apr., July, Oct	10	9⅛
180,042	10	6%	Do. 6 per Cent. Preference	14½ 15	14½ 15	4 0 0	" "	15	14⅝
150,000	10	5/0	Great Northern	19 19½	19½ 19⅝	4 6 1	Jan., April, and July	19½	19
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41 43	41 43	5 16 3	May and November	42⅛	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	7¾ 8¼	7¾ 8¼	4 16 11	April and October	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	117 122	117 122	4 18 4	" "	..	..
15,609	10	3/0	West African Telegraph xd	7 8	7 8	6 5 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	97 100	97 100	5 0 0	March & September	..	..
30,000	10	2/0	West Coast of America	3½ 4½	3½ 4½	..	January and July	4½	..
£150,000	100	8%	Do. Debentures 8% 1902	100 105	100 105	7 12 5	June and December	..	..
88,321	10	1/0	West India and Panama	1⅜ 1⅞	1⅜ 1⅞	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9 9½	9 9½	6 6 4	May and November	9 1/16	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7½ 8½	7½ 8½	7 1 2	" "	..	..
67,007	15	6 0	Western and Brazilian	10½ 10¾	10½ 10¾	6 19 5	" "	..	..
30,364	7½	6/0	Do. 5 per Cent. Cumulative Preferred	6½ 6¾	6½ 6¾	5 7 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4 4½	4 4⅜	..	" "	4 1/16	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	100 103	5 16 6	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	100 103	5 16 6	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£178,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,350	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜ ½	⅜ ½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16 1/16	1/16 1/16	6 8 11	Yearly	..	..
438,984	5	2/6	National	4⅜ 4⅝	4⅜ 4⅝	6 9 9	June and December	4 7/16	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12¼ 12¾	12¼ 12¾	4 14 1	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Prf.	12 12½	12 12½	4 16 0	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd) xd	107 109	105 108	4 3 4	January and July	108½	106
58,000	5	1/0	United River Plate	1 2	1 2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock xd	85 95	80 90	5 11 1	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£6 paid)	5½ 6	5½ 6	..	—	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..
8,332	£5	..	House to House Electric	4½ 5	..	..	..	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2½ 2⅝	2⅜ 2⅝	..	March	..	..
10,000	£5	3½%	Do. (fully paid)	4⅜ 5⅛	4⅜ 5⅛	..	March	..	..
111,000	5	..	London Electric Supply	1 1½	1⅛ 1⅜	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½ 10	9½ 10	..	..	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	6 7	6½ 7½	—	..	..	..
18,680	£5	3/6	St. James' and Pall Mall	8½ 9	8½ 9	—	..	..	..
7,900	£5	7%	Do. 7% Preference	7½ 7¾	7½ 7¾	..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	6¼ 6½	6¼ 6½	..	..	6½	6 1/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/8	Brush Electrical Engineering	3⅛ 3⅜	3⅛ 3⅜	..	..	..	..
69,996	2	6%	Do. 6 per Cent. Preference	2 2½	2⅛ 2⅜	5 1 1	..	2⅛	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares xd	5½ 6	5½ 5⅞	6 1 9	January and July	5⅞	..
17,180	5	17%	Edison and Swan United	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	6½ 7	6 6½	..	—	6⅞	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2¼ 2⅜	3⅛ 3⅜	—	—	3⅜	3
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20½ 21½	20½ 21½	4 15 3	February & August	21	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	4 5	4 5	..	..	..	..
11,334	£10	8/0	Do. Preference	8¾ 9½	8¾ 9½	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅞ 1	⅞ 1	..	..	..	..
78,919	5	5/7½	Swan United (£3. 10s. paid)	4¼ 4⅜	4¼ 4⅜	8 2 0	May and November	..	..
36,250	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July	43	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	102 105	4 15 3	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2⅛ 2⅜	..	15 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	3⅜ 3⅝	..	10 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	..	..	—	—	..	..
50,000	£10	—	City and South London Railway	2⅜ 3⅛	2⅛	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

For the first time in English history a peerage has been conferred solely for eminence in science. Sir William Thomson, as we must still call him, has already received all the honours that science can give; and as no mark of this kind can add to his fame, it is to the House of Lords and to the whole body of the scientific men of this country that we offer our congratulations. The Upper House has room for such men, and work for them to do; and while we have little fears as to its future, nothing can better conduce to its stability than the occasional selection of such men as Sir William Thomson to fill its seats. Upon science, on the other hand, an important dignity is conferred. The law is nothing if not dignified; and law lords, whether peers or no, are not uncommon. Successful tradesmen who have acquired political influence, as well as that accumulation of wealth which is considered to be the mark of success, are thus rewarded; while for mere politics the House of Lords is the natural goal of most men who succeed in that profession. Sir William Thomson has his heart in his work, and it need not be feared that he will waste his time in party politics.

The recently circulated memorandum to the President of the Board of Trade on the subject of overhead wires was put forth by the Electrical Trades' Section of the London Chamber of Commerce, under the impression that the Board of Trade had "addressed several firms engaged in electric contract work, informing them that overhead wires will in no case be allowed as a permanency." Assuming this to be correct, we commented upon "Overhead Wires and their Wardens" in a leading article four weeks ago. But question afterwards arose as to the accuracy of this assumption; and soon afterwards we learned, upon the best authority, that the Board of Trade had not made, and were not intending to make, any such drastic regulation. We left the matter in the hope that the memorandum would be backed by a sufficient number of signatures to draw from the Board of Trade a definite pronouncement on this point. No such pronouncement has, so far as we are aware, appeared; but a perfectly satisfactory solution to any doubts that may have remained is to be found in the following letter:—

[Copy.]

Board of Trade (Railway Department), London, S.W.,
4th January, 1892.

Gentlemen,—With reference to the letter addressed by your firm to the President of the Board of Trade, urging that this Department should not lay down as a settled principle that no overhead conductors for the supply of electric energy should be allowed, but that in rural districts at least the circumstances of each particular case should determine whether overhead work should or should not be sanctioned, I am directed by the Board of Trade to say that your letter appears to have been written under a misapprehension of the practice of this Department.

The Board of Trade are of opinion that, as a general rule, the use of overhead wires is accompanied by many disadvantages, both as regards the safety of the public and the efficiency of the supply of energy; and they think it is most desirable that mains for the supply of energy under Provisional Orders or Licenses should, wherever practicable, be placed under ground.

They have not, however, laid down any absolute rule that overhead wires shall in no case be employed; and while they have declined, in the absence of any special circumstances, to approve of a system in which the use of such wires was contemplated as a permanent arrangement in the central and populous portions of a town, they have, on various occasions where the circumstances appeared to justify it and the local authorities approved, authorised the employment of overhead wires in rural districts or the outlying and less populous portions of towns.

The Board of Trade see no reason to depart from the practice they have hitherto adopted of considering each application for permission to use overhead wires on its merits, having regard to the special circumstances of the district, and they will be prepared to authorise the use of such wires in any case in which they are satisfied that the interests of the public require it.—I am, Gentlemen, your obedient servant,

(Signed) HENRY G. CALCRAFT.

Some six months ago we had occasion to allude to the Parsons Steam Turbine, and observed that it was an ingenious motor which was doubtless excellently adapted for certain purposes, but that no satisfactory information on its economy had been published. These remarks, together with a misunderstanding on another matter, caused, to our great regret, some annoyance. The misunderstanding was remedied at once; and by the publication, in full, in the present issue of a report on trials conducted by Prof. Ewing, we are enabled to dismiss our doubts as to steam consumption which we held in common with many engineers, and to congratulate Mr. Parsons upon the extremely satisfactory results which have been attained. In answer to our inquiries Prof. Ewing informs us that the coils of wire on which the load was spent were single spirals, very openly wound, and were run at a high temperature, and he assumes that the correction for lag must have been unimportant. Errors due to induction would certainly be small compared with the losses which must arise from other causes to which Prof. Ewing alludes. Surprising as the figure 27·6 lbs. of steam per E.H.P. per hour will be to our readers, the consumption at three-quarter and at half loads is still more remarkable. The fact that the law connecting rate of consumption with the load is of this nature dispels the idea that this turbine is a windmill, and permits

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it to rank as a steam engine; and, as far as the present information goes, a very good one.

THE analogy that the flow of electricity bears to a current of water is so good that everyone uses it. It forms the only possible mode of describing in a simple manner the chief facts of electricity. When magnetism has to be accounted for, the analogy, however, altogether fails; and its continual use is only justifiable because, in spite of its want of completeness, it is the only clear way of regarding any large part of the phenomena of electricity and magnetism. To strain the analogy too far by seeking out analogues where no exact ones exist is, however, undesirable. Mr. MADDEN'S letter this week, by comparing a quantity of electricity with a mass of water, certainly points out a good analogue, but this end is only attained by comparing voltage with the product of a length into g, the constant of gravitation; and such a comparison is anything but satisfactory. Let analogies be retained by all means for elementary teaching, as in Mr. H. E. HARRISON'S articles; and let them be pushed occasionally, just to see where they fail, and thus to avoid misuse of them. If Mr. MADDEN had suggested that his re-arrangement made the analogy *better*, and not that it made it *exact*, it would have been more in accordance with the postscript to his letter. We hold the breakdown of this analogy to be in one sense a matter of some importance, since it tends to support our contention, that the notion of a coulomb which implies a quantity of electricity having a substantial existence is completely fallacious, and has arisen from the use of the word "current" as signifying a flow of something.

A DISCUSSION, fruitless as usual, has been carried on in the columns of the *Financial News* as to the cost of electric lighting. It was opened by a rather commonplace leading article; and a Mr. HARSTON, on whom the blessings of the supply provided by the House-to-House Company appear to be thrown away, began the correspondence by a statement of the alarming annual cost of electric lighting and the inefficiency of glow-lamps compared with gas burners. Mr. CROMPTON replied; and, forgetting for the moment that he was addressing a prejudiced audience, adopted the term "sheer cost" of production, which was used by the *Financial News* to express what our readers will readily understand to be current engine-room expenses, as distinguished from maintenance and administrative charges. But when Mr. HARSTON displayed his lack of acquaintance with the matter by supposing that Mr. CROMPTON was connected with the House-to-House Company, the latter, remembering the memorable battle of battery transformers *versus* alternate-current transformers in which he played so prominent a part, and mindful, no doubt, of the numerous points of engineering detail on which he holds diametrically opposite views to those of the advisers of the Brompton Station, to say nothing of half-forgotten opposition and emulation when the younger Company was founded, naturally replied, "Far from this being the case, instead of being connected we are in all respects their rivals and competitors." He explained the rather loose expression "sheer cost," and went so far as to say that the cost to the consumer in the future will only "bear some relation to this 'sheer cost,'" and that this "bears but a small proportion to the total cost to the supply companies." He maintained that the "sheer cost" of producing electricity by the high-pressure system as at present employed by the House-to-House Company is considerably greater than by the low-pressure system. He gave £25 as the average annual electric lighting bill for large houses in Kensington, whereas gas bills in the same houses used to be £18 to £20, the annual cost for each light fixed being from 8s. to 9s. 6d.

THE other correspondent, ignoring Mr. CROMPTON'S explanation altogether, or being unable to understand it, continued the discussion by saying that the House-to-House Company charge 8d. per Board of Trade unit, which Mr. CROMPTON says can be produced for 2d. Even a gas engineer could hardly fall into such an error. A letter then followed from a "Mechanical Engineer and Specialist," who knows so little about the matter as to suggest that a competition should be held with ten ordinary street lamps, ten high-power street lamps, and one extra high-power lamp and a few "indoor lights," the installation to be complete in itself as to motive-power, &c., and to "embrace all plant, labour, and materials necessary for the work, without the aid of any extraneous assistance whatever." The "specialist" ignores Mr. CROMPTON'S statement that the present price is high, "owing to the comparatively limited use of electricity for lighting purposes." This comparatively limited use allows of only 3,000 indicated horse-power by the Kensington and Knightsbridge Company, and yet we have a "Mechanical Engineer and Specialist," writing about "a challenge," "a penalty worth naming—say £500," and so on, for a "test" with 12 H.P. or so.

ON Monday this absurd correspondence was supplemented by a letter from Mr. GAY, the manager of the House-to-House Company. He is surprised that Mr. CROMPTON considers himself to be "a rival and competitor to the House-to-House Company, because the House-to-House Company hold sole parliamentary rights in a portion of Kensington." He goes on to misrepresent Mr. CROMPTON'S statement about the comparative cost of producing high-pressure and low-pressure electric supply, and supports his misconception by the allegation that "almost all the London Companies are charging the same price as the House-to-House Company, viz., 8d. per unit," forgetting the Metropolitan, St. James and Pall Mall, London Electricity Supply Companies, and St. Pancras, to say nothing of special contracts with the Westminster Company. Mr. GAY gives an elaborate analysis of his idea of the cost of an article, but does not give a single figure to compare with Mr. CROMPTON'S 2d. In his opinion the use of "sheer cost" "is a very erroneous way of treating the question of the cost of electricity."

A REPORT by Mr. PREECE on an electrolytic process passed through our hands a day or two ago, in which the well recognised quantity which Mr. CROMPTON calls "sheer cost"

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was set at ½d. per unit. The idea follows naturally after the "load factor" which Mr. CROMPTON has taken some pains to define. It is that quantity which is directly proportional to the output, while salaries of managers, rent, interest, &c., remain practically constant. MR. CROMPTON expresses it in a slightly different way in a letter in yesterday's issue. "We think that by the words 'sheer cost' you very happily designate that portion of the cost which is peculiar to the two systems themselves, and not the ordinary expenses of business management which are common to the two systems."

IF on any occasion we discover that our readers have been wrongly informed upon any point in the numerous matters which are discussed in these columns, we never hesitate to make a speedy and full correction. It is unwise to make corrections in haste; the second source of information may be as untrustworthy as the first. But a criticism from our excellent contemporary the *Electrical Engineer* of New York on the subject of "The Microphone in America" commands attention, if only because its facilities for mastering the subject are obviously so much greater than our own. Those of our readers who are interested in American microphones or who have a taste for American Patent Law will be glad to learn the exact mode of procedure, and for their benefit we give the comments in full. We must leave experts to decide whether any ponderous joke underlies these remarks.

"KNOCKING OUT" THE BERLINER PATENT.

The picturesque misinformation that cultivated Englishmen possess about this country is strikingly exemplified in an able editorial on "The Microphone in America," appearing in the December 4 issue of *The Electrician*. Its view of the granting of the Berliner patent is thus expressed: "It is as if one had appropriated a wrong umbrella and after wearing it out taken it back again, getting a new one in its place. You cannot do that in polite society; *but you can in the New York Patent Office.*" Our contemporary adds that "there is talk of invoking *the aid of the Legislature* to put an end to collusive and injurious 'interferences.'" It is a pity that our contemporary, who is usually so well informed and so sound in judgment, should be under the impression that the "New York Patent Office" allows this sort of thing, or that the matter is subject to the tender mercies of our State Legislature. It is the Chicago Board of Trade that is responsible in such cases, and these collusive interferences can only be put an end to by the "referendum" in the District of Columbia, or by a constitutional ballot in the thirteen original States of the Union. No doubt this is a roundabout way of correcting an abuse, but it has been carefully modeled after the precedent which requires that the Parliament of the British Empire shall sit in judgment on the wish of Puddlecombe-by-the-Haystack to have a street railway.

Appointment.—Mr. Alfred Hay, B.Sc., has been appointed demonstrator of electrical engineering at the University College, Nottingham.

Frankfort Exhibition.—The receipts of this Exhibition amounted to £75,700 and the expenses to £68,100, leaving a profit of £7,600.

Mr. Cyrus Field.—The latest bulletin telegraphed is as follows:—"Mr. Field is still confined to the house, but is slowly improving."

Railway Alarm Signal.—Messrs. Shiels and Elliot's electric alarm-bell for passenger trains was tested experimentally on the North British Railway last week.

The Western and Brasilian Telegraph Company.—This Company notifies that direct communication by its cables with Monte Video and Buenos Ayres is now restored.

Telegraph Clerks' Agitation.—The reply of the Postmaster General to the two memorials recently sent in asking for better remuneration of clerks after a few' years service, in which he declines to reopen the matter, has created considerable disappointment.

Interurban Telephony.—The Bulgarian Government has recently connected Sofia and Philippopolis (100 miles) by a telephone trunk wire.—The Paris-Nantes telephone line (225 miles) came into operation on December 21st.—The telephone line between Prague and Reichenberg was opened to the public on the 20th of last month.—A telephone line is about to be constructed between Madrid and San Sebastian, a distance of over 300 miles.

Postal Telegraph Revenue.—In the revenue returns for the quarter ending December 31, 1891, the telegraph service receipts amount to £645,000, as against £615,000 for the corresponding period of 1890, the increase being £30,000, or 5 per cent. For the first three quarters of the current financial year the telegraph service receipts amount to £1,910,000, as against £1,840,000 for the three corresponding quarters of the preceding year. The increase in this case is £70,000, or 3·2 per cent.

The Johnston System of Conduits.—The Johnston conduit patents are said to have been acquired by an English syndicate, and will be brought before the public shortly. The Johnston conduit was described by Mr. J. B. Verity in his Paper on "Underground Conduits and Electrical Conductors," read before the Institution of Electrical Engineers on April 11, 1889 (*The Electrician*, Vol. XXII., p. 715). The conduit is of iron, and is made in 6ft. lengths, and has six ducts. It has been in use in New York.

Electrical Literature.—Messrs. Whittaker and Co. inform us that they have made arrangements with the editor of *El Telegrafista Español* for the translation into Spanish of Mr. Preece's work upon "The Telephone." The book has already been translated into both French and German. The same firm will publish shortly in a cheap form Mr. A. R. Bennett's Papers on the Telephoning of Great Cities, and the Electrical Parcel Exchange System, which attracted some attention at this year's British Association meeting.

Electricity v. Gas for Street Lighting.—"What we would suggest for 1892," says the *Gas World*, "is that the gas companies of the kingdom should combine for the purpose of giving a display of street lighting in some central part of the metropolis—a display that would not be confined to a square only, but to a square and a whole street, say Trafalgar-square and the Strand. Let this section be lit up in the best manner; and after the public has seen what gas can do, publish the cost, and ask the electricians to do the same."

The Imperial Ottoman Bank.—It was decided a short time ago to light the handsome new buildings which are in course of construction at Constantinople with the electric light, and tenders were invited from a few English firms. After considerable competition the order was eventually given to Messrs. Drake and Gorham. Soon afterwards, however, the order was cancelled by telegram, as the Sultan had refused to allow the work to proceed. It is rumoured that His Majesty understood the electricity was to be generated by "dynamite," and was therefore afraid of an explosion.

The Crompton-Howell Accumulator.—In the list of London Central Lighting Stations, which appeared on p. 232 of our last issue, the secondary batteries at the Westminster Company's stations were put down as of the E.P.S. instead of the Crompton-Howell type. This printer's error will not, however, mislead many of our readers, as we think it is generally known that Crompton-Howell batteries are employed at these stations, where we understand they are "working very well indeed," as well as at Notting Hill, Bradford, Liverpool, and Birmingham. An interesting report on this accumulator will be found in our correspondence columns.

St. Pancras Vestry.—The St. Pancras Vestry have deposited a Bill, which will be introduced into Parliament next Session,

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under which powers are sought to raise £360,000 for the electric lighting of the whole of the parish, in addition to any sum that may be required for paying the costs of obtaining this Act. The period for the redemption of this loan is fixed at 42 years. The Vestry also seek power by this Bill to appropriate for electric lighting purposes the pneumatic tubes laid by the Pneumatic Despatch Company, but now abandoned, in Tottenham Court-road, Euston-road, Hampstead-road, and Drummond-street.

The Patent Office in 1891.—At the end of 1889 the applications for patents were 1,905 in excess of those sent in during 1888, this being the largest increase in any one year since the Act of 1883. At the close of 1890 there was an advance of only 299 as compared with the preceding twelve months. But during 1891 the total was 22,872, exceeding those of the previous year by 1,565. The financial position of the Patent Office is very good. The work of 1890 resulted in a surplus which exceeded £100,000; and as the operations of the office have since been conducted in a practically identical manner, there will be a still greater surplus arising from the business of 1891.

Cable and Land Line Interruptions and Repairs:

	Date of interruption. 1891.		Date of repair. 1891.
St. Thomas-St. Kitts Cable	Oct. 13	.....	*
Cayenne-Vizeu Cable	„ 22	.....	Dec. 5
Brest-St. Pierre Cable (Anglo-American)	Nov. 19	.....	*
Falmouth-Bilbao Cable	„ 24	.....	Nov. 27
Ceara-Maranham Cable	„ 24	.....	Dec. 7
Transandine Line	„ 26	.....	Nov. 27
„ „	Dec. 7	.....	Dec. 10
„ „	„ 13	.....	„ 14
Mossamedes-Port Nolloth Cable	Nov. 27	.....	„ 10
Para-Maranham Cable	Dec. 2	.....	„ 12
Rio Grande-Montevideo Cable	„ 4	.....	*
Hongkong-Foochow Cable	„ 4	.....	„ 17
Foochow-Shanghai Cable	„ 4	.....	„ 17
Hongkong-Cape Bolina Cable	„ 4	.....	*
Aden-Zanzibar Cable	„ 5	.....	*
Saigon-Bangkok Line	„ 16	.....	„ 17

* Not yet repaired.

Accumulator Cars proposed for Glasgow.—In view of the termination of the Glasgow Tramway Company's lease with the Town Council, and the probable resolution of the Corporation to work the local tramway system as a municipal concern, the Tramways Committee have lately given their special consideration to the mode of traction which they should recommend the Town Council to authorise. So far as they have been able to formulate their views on the subject, they have come to a resolution in favour of electric traction; and if they get the sanction of the Corporation to proceed further, it is highly probable that they will make a beginning with at least 50—possibly 100—accumulator cars, which it is proposed to place on one or more of the east and west tramway lines, all of which are practically level. The General Electric Power and Traction Company have offered to the Glasgow Corporation Committee on Tramways to work the cars for 5d. per car mile, a fact which has given great encouragement to the Committee.

Finsbury Special Lectures.—On January 20th, Mr. A. Reckenzaun begins a course of six lectures on Electric Locomotion, dealing with electric tramways and railways. These will be given on Wednesdays at half-past seven. Through the spring, also on Wednesdays, will be held Mr. Rousseau's practical classes in the new electroplating laboratory, in connection with which Professor Thompson will give three special lectures, on dates to be announced. On February 9th, and succeeding Tuesdays, Mr. W. C. Clinton will give a short course on vector methods of calculation in relation to electrical problems, being an introduction to the writings of Mr. Oliver Heaviside, commencing on February 9th. Professor Perry is continuing his course on the applications of the differential and integral calculus, and will conclude by an exposition of Fourier's theorem in relation to alternate currents and the use of the electrodynamometer in harmonic analysis. Professor Silvanus Thompson continues his ordinary course of Monday lectures, the topics until Easter being transformers, alternate-current motors, and the design of continuous-current dynamos.

The Weston "Flashing" Patent in the States.—There seems to be a plentiful crop of litigation pending before the American Courts. The action of the United States Electric Light Company against the Edison Lamp Company has just been concluded in Philadelphia. The plaintiff Company alleges infringement of the Weston "flashing" patent of 1884 on the part of the defendants. The history of this patent, says the *Electrical Engineer* of New York, is somewhat unusual. In 1878 Sawyer-Man and Hiram S. Maxim filed nearly contemporaneous applications for patents more or less fully describing this process. In December of that year a patent was issued to Sawyer and Man. In May, 1881, Weston made application for a patent for the same invention. After a vigorously contested interference, the Commissioner of Patents decided Weston to be the prior inventor as against Sawyer and Man, and a patent was accordingly granted to him; being the one on which the present suit is based. Considerable difficulty was experienced in procuring evidence of infringement, resort being finally had to the heroic expedient of summoning certain workmen from the Edison Company's lamp factory, and compelling them to testify. A decision is expected shortly.

An Edison Patent.—On December 8th, says the *Electrical Engineer* of New York, a patent was issued to Mr. T. A. Edison, entitled, "System of Distribution," No. 464,822, which will attract considerable attention owing to the broadness of the claims embodied in it. The patent was filed June 26, 1882, and describes the method of employing a high-tension main circuit extending to a distant point and "tension-reducers" located at a distance from the point of supply and connected with the high-tension circuit in multiple arc so as to be independent of one another, the lamps or motors on the derived low-tension circuit also being connected in multiple arc. One method of accomplishing this object is described, consisting of secondary batteries or condensers which are charged in series from the high-tension circuit and discharged in multiple into the low-tension circuit, this being accomplished by means of a revolving commutator. The patent was the subject of prolonged interference proceedings. Claim 1 is as follows:—In a system of electrical distribution, the combination of a main circuit extending to a distance from the source of electrical energy and having a current of high tension, a constantly-acting tension-reducer connected with such main circuit by a multiple-arc or cross-circuit, so as to be independent of other similarly-connected tension-reducers, and a translation-circuit supplied by such tension-reducer with a current of lower tension, substantially as set forth. The Edison Company claims that the patent covers the placing of transformers in multiple arc.

Locating Drum Armature Faults.—In the *Electrical Engineer* of New York of December 16th Mr. O. P. Loomis describes the following method of locating an armature fault:—A monkey-wrench is fastened to the rim of the pulley, or, better still, a crank to the end of the shaft. The fields are excited, and, to make the effects more marked, the coils are connected in parallel. When this has been done the strongest man will scarcely be able to rotate the armature, and then only with extreme slowness, except at one position. When this position has been found mark the armature at points opposite the centre of the pole-pieces and at both ends of the armature. The explanation is that both halves of the armature oppose one another at this position; but when not at these points a continuous circuit is formed, and the resultant magnetic effect is enormous. As the "cross" will be found at one of these four marked points it becomes desirable to know in which one it is most likely to be found. Experience has shown that it is nearly always on the commutator end in the last half of the winding where the wires pass down through the first half terminals. In armatures where the windings are equal Mr. Loomis supposes it would be as liable to be at one point as at another. With this method a defect can be found and remedied in a few moments. These results can be observed in a perfect armature by connecting the opposite sections of the commutator. When only one coil is short-circuited the magnetic effect is much less, and the points must be marked 90deg. from the ones shown; but these cases are few, and are soon discovered in other ways. The above will be understood to apply to armatures of the drum type with Siemens winding.

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THE PRINCIPLES OF ALTERNATE CURRENT MEASUREMENT.

BY HUGH ERAT HARRISON, B.SC.

(*Concluded from page 225.*)

Meters and Inductive Circuits.

A meter is intended to record the number of Board of Trade Units supplied to a circuit. The Board of Trade Unit is a unit of energy, but most meters record, not the energy that has passed into the circuit, but the ampere-hours. Indeed, no meter has yet been constructed which will, under all circumstances, measure the energy. It is assumed that the voltage between the mains is kept constant, so that the ampere-hours multiplied by the proper factor will give the number of Board of Trade Units consumed.

The record thus obtained is the same as if the voltmeter and ammeter readings in the circuit were multiplied together, the voltmeter reading being really a constant, since the E.M.F. is supposed to be constant, and the number of watts thus obtained at each instant made to show the energy consumed during the time of observation. It is clearly a matter of prime importance to know whether such a method of measurement will always give a true measure of energy supplied. It has just been shown that if the E.M.F. between the mains of an alternating current circuit would send too large

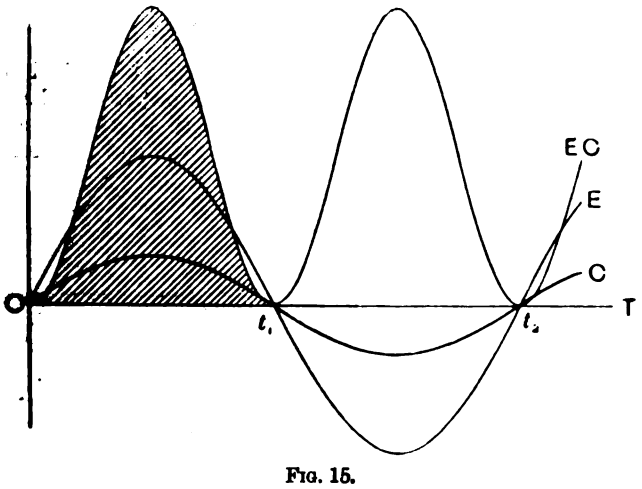

FIG. 15.

a current through any piece of apparatus the difficulty can be got over in one of two ways, the E.M.F. can be reduced to the required amount by the interposition of a resistance coil, or by means of a choking coil. In the first case the complete circuit had a certain resistance and no inductance; in the second case, the resistance was only half that of the first, but there was inductance such that the current was the same in both cases. The currents being the same, and the E.M.F.'s between the mains being the same, two meters, put one on each circuit, will register the same consumption of energy. The true amount of energy used in both circuits will now be considered.

Fig. 15 shows the first case. E is the E.M.F. between the mains, C is the current flowing; the only E.M.F. driving C is that between the mains, so that E and C always have the same direction. If corresponding ordinates of these curves are multiplied together at each instant the curve E C, giving the watts at the same instants is obtained, E C is always a positive quantity because E and C are either both positive or both negative, the E C curve is, therefore, always above the line O T, which means that the circuit is always absorbing power.

The energy used during any interval of time is got by multiplying the number of watts by the time for which they are delivered, hence, the energy during the interval of time O t_1, is equal to the shaded area contained between the E C curve and the line O t_1. If this area be measured it will be found to be exactly equal to the meter reading for a corresponding interval of time. The meter reading is, therefore, perfectly reliable where the circuit has no coefficient of self-induction.

In the second case, the E.M.F. between the mains and the current flowing are the same as in the first, the curves E and C (Fig. 16) are, therefore, reproductions of those in Fig. 15; but their relative position is changed, the C-curve, as shown in Figs. 13 and 14, lagging behind curve E.

The figure is drawn to show the position when the resultant E.M.F. is, as already stated, reduced to half that between the mains by a choking coil.

The power curve E C, whose ordinates are at each instant obtained, as in Fig. 15, by multiplying together the corresponding values of E and C, now dips below O T, for when the ordinates of E and C are on opposite sides of O T, one of them must be negative, and the negative product must be set off below this line. From t_1 to t energy is passing from the mains into the circuit, but from t to t_2 the E.M.F. of self-induction being greater than that between the mains, forces current back into them against their E.M.F., hence energy passes from the circuit into the mains. During a single pulse of the current from t_1 to t_2 the true amount of the energy absorbed in the circuit can be got by subtracting the shaded area below from that above O T, when the quantity will be found to be exactly half that used in the former case.

The meter, say a Shallenberger, is only actuated by the current; it therefore registers the same in both cases, so that the consumer in the latter case will be called upon to pay for exactly double the number of Board of Trade Units that have been supplied to him.

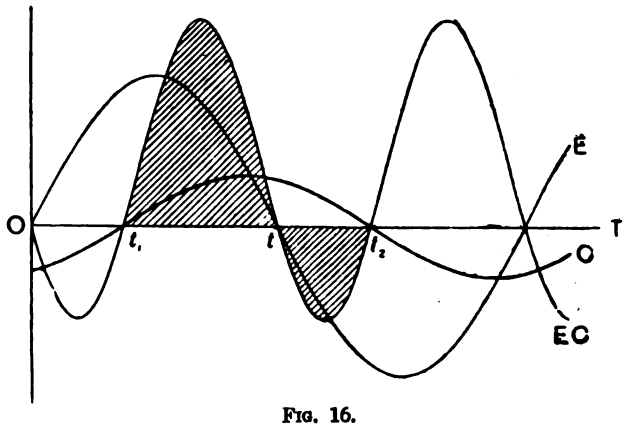

FIG. 16.

The effects due to self-induction are in many ways so unexpected, that those who are only accustomed to work with the unvarying current have some difficulty in seeing exactly how the actions, clearly shown on the curves, really do take place.

That energy *does* actually pass back into the mains and perform useful work, outside the circuit from which it has come, may be seen by taking a simple example.

Suppose that the alternating-current dynamo machine is sending current only through the inductive circuit just considered. From t_1 to t (Fig. 16), the E.M.F. set up in the armature of the dynamo is driving current in the same direction, and the steam engine has to force the armature round. At t the direction of the E.M.F. in the armature reverses, but the current does not reverse until t_2; that is to say, that between t and t_2 current is being forced through the armature against the E.M.F. set up in it. When this occurs, the dynamo is no longer acting as a generator but as a motor. During a complete revolution, for part of the time the dynamo receives electrical energy from the circuit, which it converts into movement for its own use, and the steam engine has only to supply the balance of energy required. On an ordinary circuit, however, the electricity forced back into the mains would not return to the central station, but pass on to supply lamps in a neighbouring house, thus lessening the current the machine has to supply.

From t_1 to t the circuit is, on the whole, absorbing more energy than it can use, so that from t to t_2 it returns what it

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does not convert into heat; at first it may not be obvious where this energy is stored. The storage of energy received, and subsequently returned, as electrical energy is nothing new. When a current is forced through a secondary battery, but a small fraction of the energy absorbed immediately reappears as heat; the energy is stored up in certain lead compounds, which will give out electrical energy on being allowed to return, by chemical action, to their former state.

When a current passes through a coil having self-induction lines of force spring from it linked with the conductor carrying the current, here it is that the energy is stored, not simply in the coils, but in the space around them pervaded by these lines. When the current falls to zero these lines collapse, and disappear from whence they sprung, but while so doing cut through the path of the current, and return the energy they originally carried with them. The energy stored up at any moment in this form is easily found by multiplying together the ordinates of current and E.M.F. due to self-induction between the point under consideration and that in which the current is zero. The area of the curve so obtained can be shown to be equal to $\frac{1}{2}$ S C^2, S being the coefficient of self-induction.

Conclusion.

It has been assumed that no iron has been used in the circuits through which alternating currents have passed. This has been done in order that varying electromotive force and current might be represented by sine curves, as indeed, is almost always the case in mathematical treatises. In practice a considerable quantity of iron is used with the result that the curves are not true sine curves, and the variation curves are still further departures from them.

The constructions given, however, still hold, the only difference being that the diagrams look more complicated and require more care and skill to draw. Again, the iron causes loss of energy from the circuit, in addition to that due to the resistances of the conductor. Iron, however much laminated, becomes hot when rapidly magnetised and demagnetised. In a choking coil wound with an iron core, therefore, there would be a certain loss even though the coils were of negligible resistance. The aim of this Paper is, however, to be qualitative rather than quantitative, and to explain in their simplest possible forms certain phenomena of the utmost importance, but not very generally understood.

NOTES ON THE PRODUCTION OF A ROTATING MAGNETIC FIELD.

BY H. J. S. HEATHER.

The amount of attention which has recently been devoted to the production of alternating-current motors by the help of a rotating magnetic field, and the very practical advantages that might be secured by the abolition of the commutator, especially in mining machinery, by the adoption of such a system, have led the writer to investigate the claims put forward by Herr Dolivo-Dobrowolsky, in the *Elektrotechnische Zeitschrift*,* of having reduced the pulsations in magnitude of such a field from 40 to 15 per cent. by using three currents, each lagging 60° behind that preceding it, instead of two differing in phase by 90°. This claim, it will be remembered, was based upon the assumption that the currents obtained from an alternator could be represented by sine curves. Recent investigations, however, such as those of Dr. Fröhlich† and Mr. W. B. Lewis,‡ have shown that such a conclusion, although to a certain extent justifiable on theoretical considerations, cannot be regarded as even approximately correct in practice. That the results obtained will necessitate considerable modifications in the figures given by Herr Dobrowolsky is rendered evident in the accompanying Figs. 1 to 8. The curves here given show the nature and extent of the variations which may be expected to actually occur in the strength of rotating fields produced on the two-phase and the three-phase systems. The curves have been obtained from those published by Mr. W. B. Lewis; and in order to facilitate

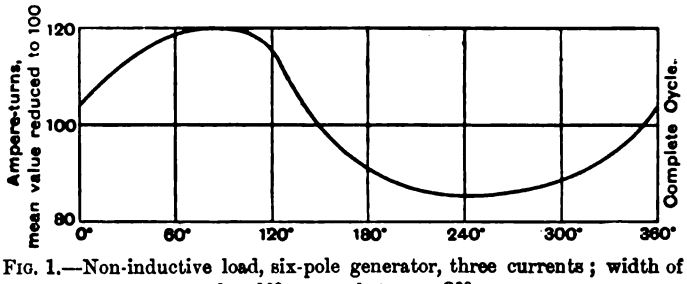

FIG. 1.—Non-inductive load, six-pole generator, three currents; width of poles, 40°; space between, 20°.

comparison reductions have been made, so that in all cases the mean value of the ampere turns is represented by 100. The total variation can consequently be read off as a percentage of

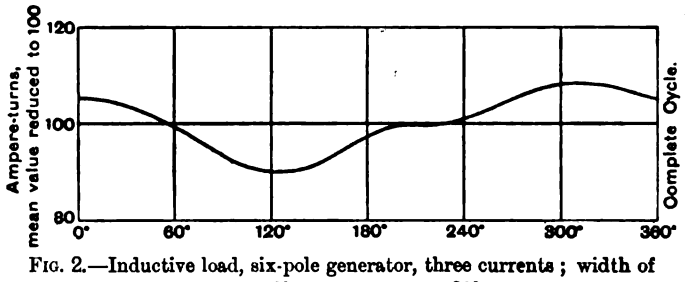

FIG. 2.—Inductive load, six-pole generator, three currents; width of poles, 40°; space between, 20°

the mean value, which seems a more logical method of procedure than that adopted by Herr Dobrowolsky. The latter gives for the variations in the field strength on the two and three-phase systems respectively the figures 40 and 15 per cent.

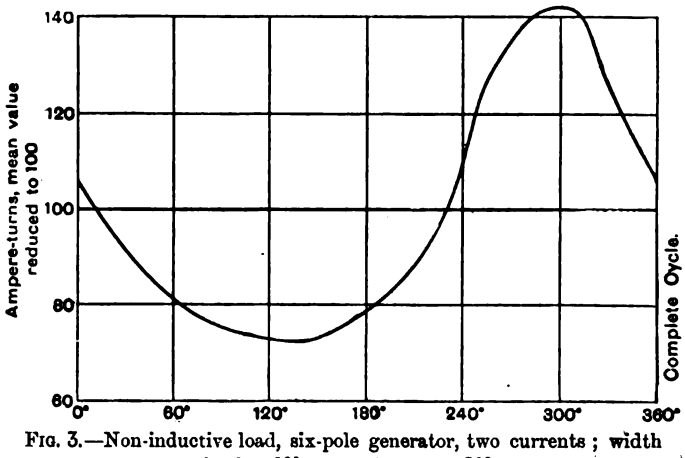

FIG. 3.—Non-inductive load, six-pole generator, two currents; width of poles, 40°; space between, 20°.

These being taken on the maximum values will have to be altered to 32 and 14 per cent. respectively, in order to be compared with the results given herein, in which, as above explained,

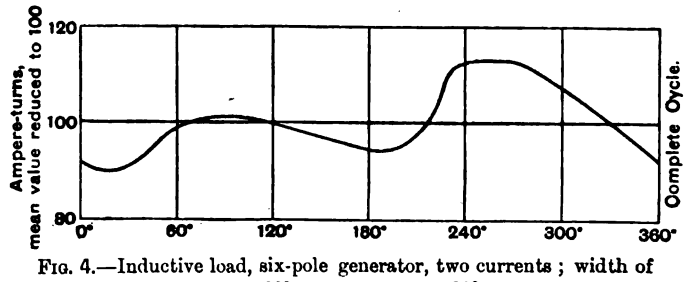

FIG. 4.—Inductive load, six-pole generator, two currents; width of poles, 40°; space between, 20°.

the variations are given as percentages of the mean values. Figs. 1 and 2 are ampere-turn curves obtained by combining three curves similar to those designated as curves 2 and 3 on p. 91 of Vol. XXVIII. of *The Electrician*. The angular width

* *The Electrician*, Vol. XXVII., p. 389.
† *The Electrician*. ‡ *The Electrician*, Vol. XXVIII., p. 91.

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of the pole-pieces in the machine furnishing this current was 40deg., and the space between them 20deg. In Fig. 1, the load was non-inductive; Fig. 2 being obtained from the inductive load curve given on p. 91. The variation in the former case amounted to 34 per cent. of the mean value, whilst in the latter it is 18 per cent.

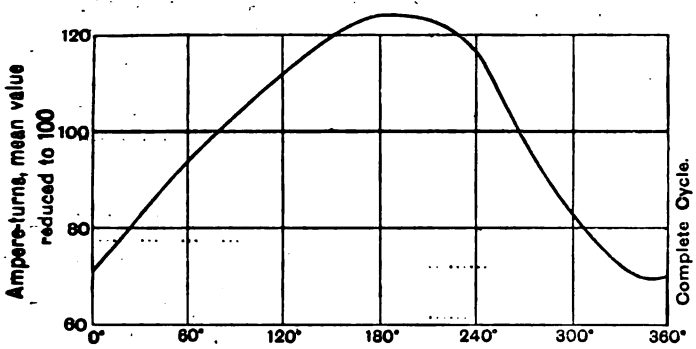

FIG. 5.—Non-inductive load, six-pole generator, three currents; width ..... of poles, 30°; space between, 30°.

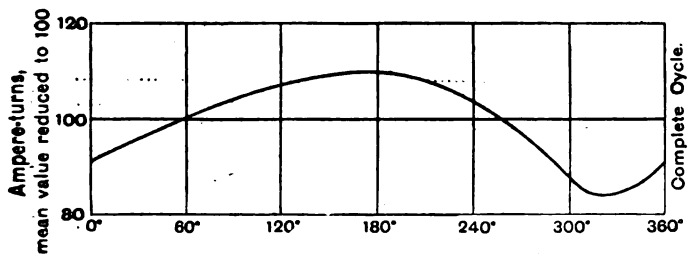

FIG. 6.—Inductive load, six-pole generator, three currents; width of poles, 30°; space between, 30°.

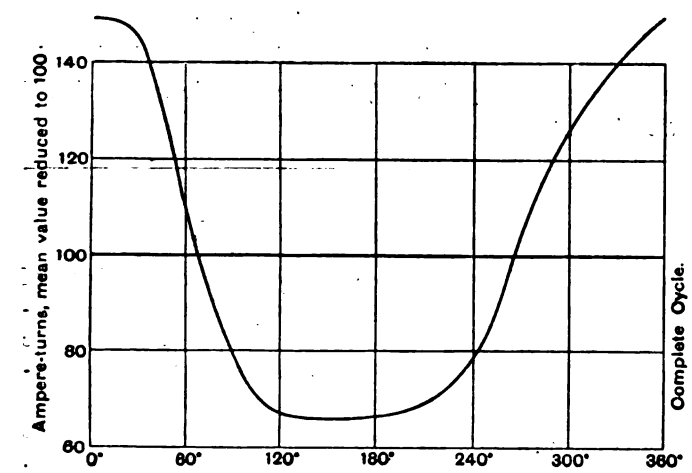

FIG. 7.—Non-inductive load, six-pole generator, two currents; width of poles, 30°; space between, 30°.

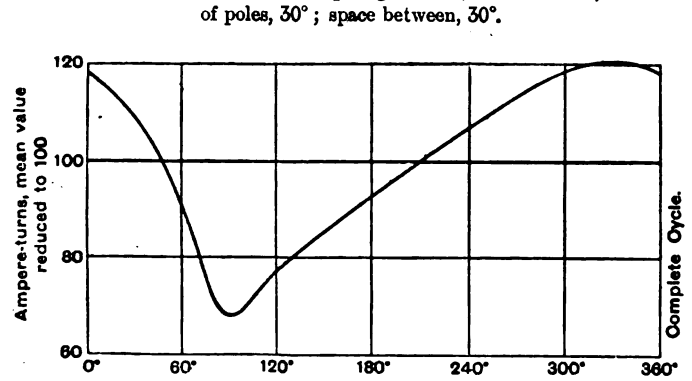

FIG. 8.—Inductive load, six-pole generator, two currents; width of poles, 30°; space between, 30°.

Figs. 3 and 4 give the results of combining two currents from the same machine, differing in phase by 90deg. The variations here become 70 per cent. and 23 per cent. for inductive and non-inductive loads respectively.

Figs. 5 and 6 give the curves for ampere turns on non-inductive and inductive loads, as obtained by combining three currents supplied by a second machine. The variations here are 54 and 28 per cent. Using two currents only, of the same machine, we get Figs. 7 and 8, showing variations of 83 and 52 per cent. The machine used in these four curves had pole pieces, the breadth of which was 30deg., the space between them being also 30deg.

On considering the results obtained it is obvious, firstly, that the design of the machine employed to furnish the multiple-phase currents is of much more importance than the choice between the use of three currents and two; and secondly, that in a machine properly designed for the purpose the advantage gained in steadiness of field strength by the use of three currents instead of two is not nearly so great as Herr Dobrowolsky would have us suppose. Taking, for example, the curves obtained on inductive loads from the machine with the broader poles, we find that the variations are reduced only from 23 per cent. to 18 per cent., instead of from 32 per cent. to 14 as would be the case if the currents could be represented by sine curves. From this it seems clear that the gain in steadiness, amounting only to 5 per cent., secured by the use of three currents with four leads, cannot be considered to correspond with the expense incurred by laying the fourth lead. With regard to the possibility of conveying the three currents by three wires, it may be pointed out that this can only be done at the cost of efficiency, as, owing to the fact that the currents do not in reality follow sine curves, it follows that the sum of two of them is not at all times equal to the third, and consequently at times the volts in two of the sets of coils of the generating machine are attempting to drive a current through the third coil in opposition to that which is induced therein.

BOOKS, &c., RECEIVED.

"Traité Pratique d'Électricité." By Felix Lucas. (Paris: Baudry et Cie.)

"Annuaire pour l'An 1892. (Paris: Gauthier-Villars et Fils.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

TUESDAY, January 12th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read with a view to discussion: "Weighing Machines." By Wilfrid Airy, B.A., M. Inst. C.E. At this meeting the monthly ballot for members will be taken.

THURSDAY, January 14th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. General Meeting. Presidential Address on "Electrotechnics," by Prof. W. E. Ayrton, F.R.S.

FRIDAY, January 15th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read: "Testing and Inspecting for Commercial Purposes." By J. Roxburgh Sharman, Stud. Inst. C.E.

JUNIOR ENGINEERING SOCIETY.

8 p.m. Ordinary Meeting. Paper to be read: "Modern Applications of Electricity to Metallurgy." By George C. V. Holmes, Sec. I.N.A.

SATURDAY, January 16th.

ASSOCIATION FOR THE IMPROVEMENT OF GEOMETRICAL TEACHING.

11 a.m. General Meeting at University College, London. Reports to be presented. Election of Officers.

2 p.m. Papers to be read: (1) "On Laguerre's Dictum concerning Direction." By Prof. R. W. Genese, M.A. (2) "On the Geometrical Interpretation of Fallacy in Elimination." By Prof. R. W. Genese, M.A. (3) "On the use of Horner's Method in Schools." By E. M. Langley, M.A.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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The Electrician.

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NOTICE.

With our next Number we shall issue, as a Supplement, a **COLOURED MAP,** *showing the Electric Supply Mains laid in London up to January 1, 1892, together with the areas allotted to the different Supply Companies.*

THE SPREAD OF SCIENCE.

The continual increase in the industrial applications of science has brought about quite a revolution in our educational system, involving a much wider diffusion of scientific knowledge than in former times, at the expense of scholarship, culture, development and training of the mind and character, or, in other words, that preparation for complete living which is the function education has to discharge. Education and culture have been confounded with, and are being swamped by, instruction and teaching. Accepting the situation, however, we are confronted by the fact that after the mere elements have been acquired from text-books, a student who wishes to take up more advanced work, and to make himself familiar with recent developments and applications, must turn to Papers read before, or presented to, learned societies. Now the extent to which the publication of Papers on scientific subjects has developed owing to the multiplication of colleges and universities and of scientific societies is enormous. Twenty years ago it was comparatively easy for a scientist to keep himself in touch with all the experimental work carried out in connection with his own special department; but this is now quite out of the question, in consequence of the great number of workers and the endless publications that would have to be perused in order to accomplish his object. Science is no longer a purely intellectual calling, followed from the love of knowledge or the desire for fame. Its commercial applications have become so numerous and important that many follow it for mere gain. The advantages

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thus accruing to science are of considerable value, and although commercial men still sneer occasionally at abstract scientific investigation, the great debt which industry indirectly owes to pioneer work has been more than repaid by rich endowments of general research, and by a number of large scale industrial developments which have had a marked influence on the progress of pure theory. The theoretical importance of the induction researches of FARADAY could not have been recognised to anything like their full extent had it not been for the development of the dynamo machine; while the investigations of HERTZ and MAXWELL'S great theory which explains them, would have been unintelligible, save to a few mathematicians, were it not for the familiarity with alternate-current phenomena brought about by commerce, and by commerce alone.

These developments are, however, not all healthy, for, in some respects, scientific progress is being choked by its own rapid growth; and while scientific papers increase in number they do not increase in value. Nowadays each town wants an educational establishment which calls itself a university, and each of these has its physical society. Formerly scientific publications were few and expensive, and it was always worth while to attend the meetings of a scientific society. But it is now possible to procure, at a trifling cost, weekly or monthly publications which reproduce, in full or in abstract, the more important of the current Papers published in all parts of the world. These can be read in leisure moments, and the articles which do not interest can be passed over; whereas attendance at a meeting involves a great expenditure of time, and often results only in the hearing of a dull or poor Paper. This fact may serve to explain the absence of many of the best, and hence the busiest, men from scientific discussions; and, indeed, there are so many societies now that a feeling of satiety is excusable. The technical journals are to a great extent usurping the functions of the scientific bodies by publishing original matter straight away; and many prefer this method of giving their results to the world because it secures wider and prompter publicity, and because there is not so much danger of a valuable Paper being lost when it is printed in the columns of a widely circulated journal. This danger of burying a good Paper amid the bewildering mass of contemporary science is by no means imaginary, and is becoming greater and greater every year. People have very little time to read Papers, and they have much less time to criticise them. The hasty way in which people read has naturally a bad effect on those who write, and but few Papers now are well and clearly written. Many rush into print with experimental matter the results of which are too incomplete to be really worthy of publication; while others who are well qualified to speak with authority are far too busy to find time to put into proper publishing form the great mass of interesting and important results constantly occurring in the course of their work. There is too great a tendency on the part of writers to expand mere details in order to make a lengthy communication.

Things have already come to a such a pass that it is almost impossible for anyone to read more than a fraction of the literature referring to his own special class of work, and science is spreading so rapidly that in the near future matters may be expected to be much worse. It is not easy to suggest a remedy. What perhaps is needed is a clearly written and complete series of classified abstracts, giving the gist of what has been published. The question of ways and means, important as it is, is, however, hardly the most difficult one to solve. The greatest difficulty would be to find properly qualified men to do the work. The qualities of a good literary reviewer are not at all those which are needed for the scientific abstracter. In the former we look for well-balanced comments and personal opinions, while in the latter we want clearness and brevity in the exposition of difficult matter and the total abandonment of everything personal. Nothing is more difficult than really good abstracting, and the author himself is often quite incapable of generalising his results and expunging details. The abstracter must be interested in his subject; that is to say, he must be experimentally familiar with it; and the matter must be somewhat fresh to him, or he will grow tired, fail to grasp the Paper as a whole, and make an unsatisfactory summary. The scientific societies could do much to forward this work either singly or in combination. We have already pointed out that the technical Press has relieved these bodies of the need of publishing results, and the aim of societies should now rather be the discussion of Papers which have *not* been read before them, than, as too often happens, the reading of Papers at such length that no time is left for discussion. The *raison d'être* of all societies and similar institutions is the bringing together of birds of a feather for the critical examination of new devices, discoveries, and theories, and the collection and editing of scattered scientific memoirs. It is true that some of the societies attempt work of the latter kind. The Physical Society have translated and published some very valuable foreign memoirs. The Chemical Society issue with each section of their Journal an important series of abstracts. The Institution of Civil Engineers has a regular staff of translators and abstracters, who collect descriptions of new works, inventions, and processes from foreign journals, as well as Papers presented to learned societies. The Institution of Electrical Engineers does a little less of this kind of work every year. Methodical abstracting is, however, becoming more and more necessary to prevent valuable matter from being utterly lost, and this work is clearly the business of the scientific societies.

OBITUARY.

SIR GEORGE BIDDELL AIRY.

The death of Sir George Airy removes from the general scientific world a most rigid mathematician; while the mathematical world loses one who has for the last seventy years devoted his rare abilities to the application of mathematics to astronomical and allied problems. Sir George Airy was born in 1801, entered Trinity College, Cambridge, in 1819, and graduated as Senior Wrangler in 1823. In the next and following years he published Papers on Lunar and Planetary Theories, the Figure of the Earth, Undulatory Theory of Optics, the Forms of the Teeth of Wheels, and on Escapements. In 1826 he was elected Lucasian Professor of Mathematics, and, two years later, Plumian Professor of Astronomy. From this time he applied himself with the greatest activity to both the development of important planetary and other astronomical theories, and to the arrangement of the routine of observations, upon which all good observatory work depends. In 1836 he was appointed Astronomer-Royal. It is not necessary to allude here to the invaluable services which he rendered to exact astronomy during his long tenure of office; but we must not allow the establishment of magnetic observations at Greenwich to pass without mention. Amongst other useful work outside the observatory, Sir George Airy turned his attention to the deviation of the compass in iron ships, and was Chairman of the Commission appointed to consider the general question of Standards, and of the Commission intrusted with the superintendence of the new standards of length and weight after the fire which destroyed the Houses of Parliament in 1834.

The best known work of Sir George Airy is his "Treatise on Errors of Observation," published in 1861. Nine years afterwards he published a "Treatise on Magnetism"; and in the

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following year (1871) he was elected President of the Royal Society. He was a man of immense industry and highly-trained intellect, and a severe disciplinarian. His mathematical powers were of that kind which are best applied to specialist's work; and his official position as Astronomer-Royal, in directing his attention mainly to that science which first occupied his attention as a young man, concentrated his energies on work for which he was eminently fitted, and resulted in the development and equipment of the Greenwich Observatory, the organisation of eclipse and transit expeditions, and the still more permanent record of his labours in the bulky volumes which contain the reduction of observations and other direct contributions to astronomical science.

FREDERICK RICHARDS LEYLAND

Mr. F. R. Leyland, the Chairman of the National Telephone Company and Deputy-Chairman of the Edison and Swan and also of the Swan Company, died very suddenly on Monday afternoon last. Mr. Leyland, after spending some hours at the Telephone Company's office, left with Colonel Raynsford Jackson, both gentlemen going to Cannon-street Station of the underground railway. After leaving that station he became very ill, and at Blackfriars he had to be taken out of the train, and a doctor was sent for, who, on arrival, found him dead. Mr. Leyland was 61 years of age. The death of Mr. Leyland will prove a serious loss to the Companies with which he was connected. Since his appointment to the Presidentship of the National Company he had thrown himself heartily into the work, and devoted almost all his time to the business of the Company, although he was a man of wealth, and had retired from active business before his connection with the telephone company began.

Mr. Frederick R. Leyland, who was head of the great shipping firm of Liverpool known as the Leyland Line, has passed the greater part of each year for several years past in London, leaving the executive responsibility of the business in Liverpool to his son, Mr. Frederick D. Leyland, and his manager, Mr. Martin, though he has always spent the autumn in Liverpool. Mr. Leyland's career was most remarkable. At an early age he was placed in the office of the well-known shipping firm of Messrs. Bibby and Co. By his talent and industry he rose to be manager of the firm, and while still a young man was taken into partnership. When some years ago the partnership came to an end by effluxion of time Mr. Leyland carried on the business alone, since which time he has extended the business very much, and has been for some time probably the largest and most wealthy individual owner of ships in the world.

Shortly after the Edison Company was formed, in 1882, Mr. Leyland was invited to join the Board. He, however, had only attended two or three Board meetings when the amalgamation with the Swan Company was resolved upon, and he became one of the first Directors of the Edison and Swan Company; and at the end of the first year of the amalgamated Company he was appointed Deputy-Chairman. His colleagues, one and all, have always recognised that no small share of the success which has attended the "Edison and Swan" has been due to the courage, the ability, the industry, resource, and resolution of Mr. Leyland, than whom no better man of business has ever migrated from Liverpool to London. In December, 1884, he became a Director of the Swan Company, and he has devoted a great deal of time and has spared no effort to make both of these electrical companies worthy of the great industry with which they are concerned.

About three years ago Mr. Leyland was invited to join the Board of the United Telephone Company, and took an active and leading part in the delicate and difficult negotiations preceding the amalgamation which resulted in the formation of the important Company which works throughout England under the name of the National Telephone Company, of which at the first meeting of the Board he was chosen President. Since his appointment as President he has thrown his whole energy into the work; he has attended in Oxford-court three or four days a week, and for many hours a day, and the great increase in the business, and the encouraging prospects of the Company, are in no small degree due to Mr. Leyland's devotion to the interests of the concern.

Mr. Leyland was a man of great wealth, his house in Princes-gate, known throughout the world for its beautiful "peacock room," decorated by Mr. Whistler, contains the best collection in London of pictures by Boticelli, Rossetti, and Burne Jones. Mr. Leyland leaves one son and two daughters, Mrs. Val Prinsep and Mrs. Speed. Mr. Leyland was a self-educated man; he knew and could speak French, Italian, and Spanish, besides being a great lover of art and a consummate judge of pictures; he played the piano admirably, and often, after a hard day's business, he sought relaxation by playing the masterpieces of Beethoven, Mozart, Liszt, and Chopin by the hour together. There are not many more remarkable instances to be found in the annals of commercial life than the rise of Frederick Richards Leyland from the humble position of a boy in the office to the head of the great firm of "Leylands," of Liverpool, teaching himself, as he did, arithmetic, French, Italian and history—even when 14 years of age working on night after night at these subjects till 2 a.m. in order to try to make up for the stern necessity which, owing to his father's death, sent the poor little uneducated Lancashire lad, at 13 years of age, to earn his own laborious and precarious living.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 192.*)

§ **47. Elementary Theory of Circular Circuits.**—We shall now consider a few cases in which the coefficient of mutual induction, M, for a pair of circuits can be easily calculated, and shall also determine the force acting between them. Let there be two circular circuits, with their planes parallel, and the line joining their centres perpendicular to these two planes. Let A, Fig. 42, be the radius of the larger, a that of

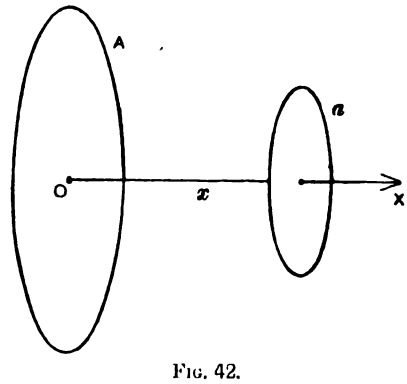

Fig. 42.

the smaller circle, and x the distance between the centre of the circles. To find M we have to find the number of lines of induction which pass through a (carrying no current) when unit current flows in A. In this case we shall make use of the "First Method" of § 43. If a is small compared with A, we may consider that the magnetic induction is uniform all over the plane area bounded by the circle a. By § 26 or § 33, the magnetic force at a point on the axis at a distance x from the centre of the circle A, due to unit current in A, is $F = 2\pi A^2/(A^2+x^2)^{\frac{3}{2}}$, and its direction is along the axis. Since we are dealing with air, this is also the magnetic induction. Hence the number of lines of induction which pass through a, whose area is πa^2, is $M = 2\pi^2 a^2 A^2/(A^2+x^2)^{\frac{3}{2}}$ per unit of current in the coil A. If currents, i, i', flow in the same direction round the circuits A, a, then, by § 44, the force acting on a tending to increase x, is $X = i\,i'\,dM/dx$ dynes. Hence, in our case, $X = -6\pi^2 a^2 A^2 x\,i\,i'/(A^2+x^2)^{\frac{5}{2}}$ dynes, the negative sign implying attraction. When x is small compared with A the force is nearly proportional to x, but when x is large compared with A, then the attraction is nearly proportional to $1/x^4$, so that it

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very soon becomes exceedingly small. To find when the attraction is a maximum we must put $dX/dx = 0$. Performing the differentiation we easily find that this condition is satisfied when $x = A/2$. When the coils are placed at this distance apart the force between them has its greatest value, and consequently is not altered by any very small change in x. To give some idea of the magnitudes of the quantities we are dealing with, we have calculated M and dM/dx for various values of x taking A = 50cm. $a = 10$cm. We notice that since M is of the *dimensions* of a line dM/dx is a pure number and is quite independent of the standards of length, mass, or time. When multiplied by the product of the two currents it gives the force in dynes.

x centimetres.	M centimetres.	dM/dx.
0	39·47	0
10	37·21	·4294
25	28·2491	·677963
50	13·95	·4187

If there are n turns on the coil A and n' on the coil a, and the windings occupy a space which is very small compared with the radius of either coil, both M and $d\,M/d\,x$ will be $n\,n'$ times as great as before. Thus, if there were 1,000 turns of wire on the large coil and 100 on the small one, we should have when $x = 25$ cm. $M = 28{\cdot}2491 \times 10^5$ centimetres $= {\cdot}0028491$ henry, $d\,M/d\,x = {\cdot}677963 \times 10^5$.

Now, suppose that the same current of 1 ampere is flowing in both coils. The value of the ampere in C.-G.-S. units is 1/10. (*See* § 23.) Hence the *attraction* between the coils under these circumstances is $-X = -i\,i\,d\,M/d\,x = {\cdot}677963 \times 10^3 = 677{\cdot}963$ dynes. But the *weight* of 1 gramme at Greenwich is 981·17 dynes, so that X is equal to the weight of ·6909 grammes at Greenwich.

§ 48. **Elementary Current Weigher.**—If we can actually measure this force we can at once deduce the value of the current flowing in the two coils without any reference to such

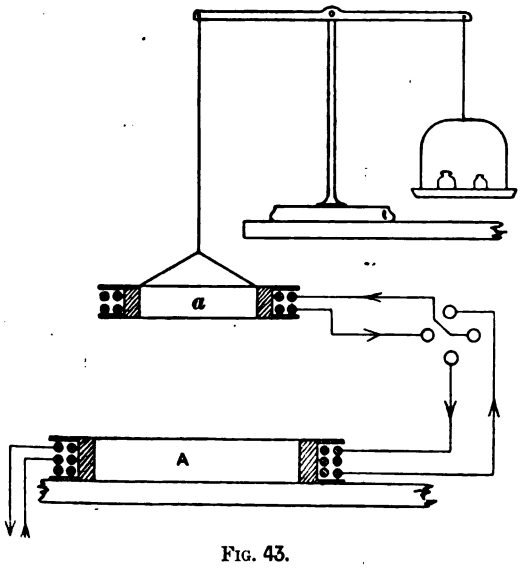

Fig. 43.

uncertain quantities as the strength of the Earth's Horizontal Magnetic Field, as in the case of the Tangent Galvanometer. The force of attraction can be measured by suspending the small coil from an arm of a balance (Fig. 43). The same current is sent round both the coils A and a, being led to and from the latter by a number of very flexible copper wires arranged "in parallel." A commutator is arranged so that the current in the suspended coil can be reversed without reversing that in the fixed coil. When the currents flow in the *same* direction, the electro-magnetic force is an *attraction*, when they flow in *opposite* directions a *repulsion*. The weight of the difference of the masses required to balance the suspended coil in the two cases is twice the electro-magnetic force experienced by that coil in either case. If $2m$ is the difference of the masses in grammes, and g the value of "gravity," we have

$$m\,g = \frac{6\,\pi^2\,n\,n'\,A^2\,a^2\,x}{(A^2+x^2)^{\frac{5}{2}}} \cdot i^2,$$

where n, n are the numbers of turns on the two coils. From this equation we can at once determine the value of i.

Since the force depends upon i^2 it is independent of the direction of the current, so that this method is available for the measurement of an alternating current. In this case the value of i deduced from the equation gives the square root of the time-average of the square of the current. This is called the "effective current," as an English equivalent of the definition agreed to at the Electrical Congress at Paris in 1889. (*See* report on "Electrical Standards," British Association Report, Newcastle, 1889.)

§ 49. **Best Positions for the Coils.**—We gain considerably in accuracy by placing a second fixed coil on the other side of the suspended coil, the second coil being exactly similar to the first. Let the planes of the two fixed coils be at a distance $2\,b$ apart, and let the suspended coil be at a distance $b+z$ from one fixed coil, and consequently at a distance $b-z$ from the other; z is supposed to be small. We then find by Taylor's theorem that the values of $\frac{d\,M}{d\,x}$ for the suspended coil and each of the two fixed coils are

$$x = b+z,\quad \frac{d\,M}{d\,x} = \left(\frac{d\,M}{d\,x}\right)_b + z\left(\frac{d^2\,M}{d\,x^2}\right)_b + \frac{z^2}{1\cdot2}\left(\frac{d^3\,M}{d\,x^3}\right)_b + \ldots$$

$$x = b-z,\quad \frac{d\,M}{d\,x} = \left(\frac{d\,M}{d\,x}\right)_b - z\left(\frac{d^2\,M}{d\,x^2}\right)_b + \frac{z^2}{1\cdot2}\left(\frac{d^3\,M}{d\,x^3}\right)_b - \ldots$$

where the suffix b attached to any quantity means that x is to be put equal to b in that quantity *after differentiation*. The sum of these two expressions is

$$2\left\{\left(\frac{d\,M}{d\,x}\right)_b + \frac{z^2}{1\cdot2}\left(\frac{d^3\,M}{d\,x^3}\right)_b\right\} + \ldots$$

so that the error introduced by a small displacement of the suspended coil from the central position depends upon the square of that displacement. Hence, with moderate care in the adjustments, the force experienced by the coil may be considered to be the same as in the exact central position.

We may make the force in a very high degree independent of small displacements if we chose b so that $(d^3\,M/d\,x^3)_b = 0$, since the first term which then appears involves z^4 and hence is extremely small. In our case we find that $(d^3\,M/d\,x^3)_b = 0$ when $b = A.\sqrt{3}/2$, but the attraction is now only ·747 of its maximum value.

If we can effect the centering of the suspended coil with sufficient accuracy we gain an important advantage in making $b = A/2$, so that the attraction is a maximum, since it is then practically independent of small variations in the distance between the two fixed coils. For if we always place the suspended coil midway between the two fixed coils we have $d\,M/d\,x = -6\,\pi^2\,a^2A^2\,b/(A^2+b^2)^{\frac{5}{2}}$ which is a maximum and therefore independent of small changes in b when $b = A/2$. Putting in this value we find $d\,M/d\,x = -6\,(\frac{4}{5})^{\frac{5}{2}}\,a^2/A^2$ which depends only on the ratio a/A and not on any absolute measurements of lengths. The ratio a/A can be found by the electrical method given in § 29 with very great accuracy. The fact that the fundamental "constant" of an instrument of the class we are describing depends only upon the ratio a/A is most important; we shall return to it again when we deal with Lord Rayleigh's work.

(To be continued.)

Lightning Conductors in Germany.—A report, says *Industries*, has been recently issued, giving a list of public buildings struck by lightning in Germany, during the period 1887-88. The total number was 264; only 15 of the buildings struck were provided with lightning conductors, and in 14 of those the conductors were in a very bad condition.

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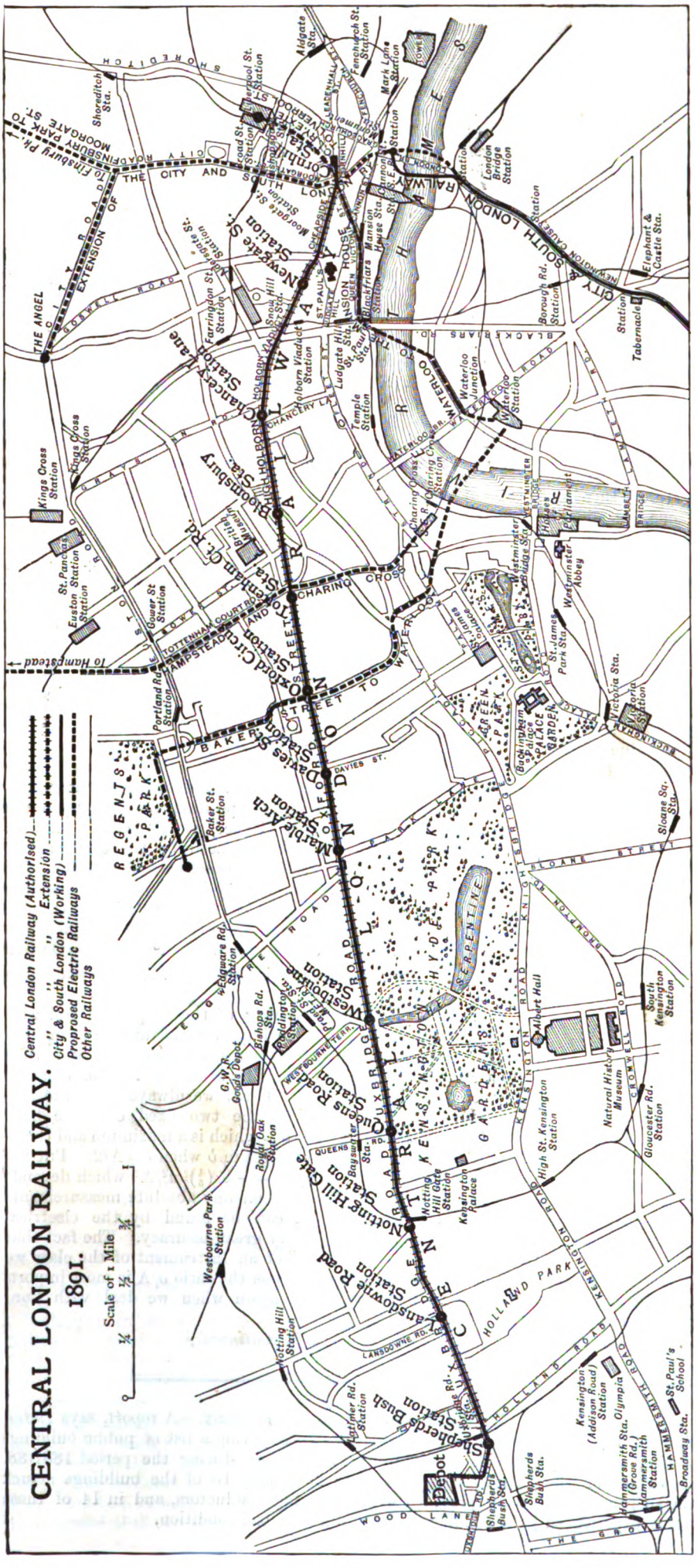

ELECTRIC RAILWAY ENTERPRISE IN LONDON.

The first point to be noted on the map which we publish this week is the route of the existing Underground Railway, the "circle" of which is somewhat of an oblong, being about five miles long by two miles broad, circumscribing the very heart of the metropolis. The weak feature of the Underground Railway is, however, that it is circular; it rarely happens to be the shortest route to a given place. Another defect is that, although closely adjacent at different points to all the termini of the large trunk lines, it does not actually run through any of them, with the exception of Cannon-street. Paddington, Victoria, and Liverpool-street, are, indeed, accessible by means of subways; but with the far more important Stations of Euston, St. Pancras, and King's Cross there is no "physical junction." The electric railways now in operation, authorised, and projected, propose to meet these and the many other still more serious defects of the existing Underground Railway.

The Central London Railway, with its proposed extension from the Mansion House to Liverpool-street Station, will cut straight across the heart of London from East to West, connecting the residential districts of Bayswater and Notting Hill with the shops of the West and the business quarters of the City. It is not unreasonable to expect that this line will have a fairly heavy *all day* traffic; since after the rush of the business men going inwards in the morning, there will be a constant stream of "shoppers" out and home before the return rush from the City takes place in the evening. The line from Waterloo across the West End to Baker-street supplies a long-felt want, for between the large residential districts north of Baker-street and the leading thoroughfares of the West End, there is at present no adequate mode of conveyance. The line which it is proposed to run from Charing-cross to Hampstead Heath will make this "open space" easy of access, and will also place an important residential district in closer communication with the shopping and business quarters of London. Perhaps the line most needed is the short one from Waterloo Station into the City. Hundreds of suburban and main line trains run in and out of Waterloo every day; and yet the only means of getting across the river into the City has been by a circuitous railway journey, the omnibus, or cab. The extension of the City and South London Railway northwards into the populous district of Islington will probably prove a very profitable one to that Company, since, so far as direct railway communication is concerned, the North and South of London are at present almost entirely cut off from each other. The line from Finsbury Park to Finsbury-pavement will, it is to be hoped, diminish the sometimes dangerous and always disgraceful overcrowding of the Great Northern trains running in and out of Moorgate-street.

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The fate of the four new lines and two extensions which will come before the Legislature this Session depends, of course, on the exigencies of the political situation. If Parliament is dissolved suddenly and early, we may say good-bye for the next twelve months to all of these enterprises.

THE CRYSTAL PALACE EXHIBITION.

We have visited the Crystal Palace with the object of being able to give our readers some idea of what may be ready for inspection on Saturday, when the Exhibition is to be formally opened. Two or three days, however, will no doubt largely increase the number of completed stalls, which were but few and far between at the time of our visit. Among those which may be expected to be quite ready is the Post Office exhibit, which will be one of even greater interest than usual. The instruments will be arranged in chronological order on four tables, each about 100ft. long—the tables being arranged in pairs. On one pair will be instruments used during the period 1851—1870, and on the other pair those subsequently in use down to the most modern.

The Brush Company's space was well filled with trim and compact little combined plants, consisting of "Brush" engines coupled direct to "Victoria" dynamos. Some of the latter have the field-magnet coils enclosed in metal cases, and look an exceedingly good job, the finish and workmanship alike being first class. Mordey alternators were in course of erection; and a number of transformers in cast-iron cases, each having a switch—presumably, on the primary—the lever of which projects through the casing and ends in a porcelain handle, were lying about the stand. One of the hollow wrought-iron poles for arc lamps, having all the gear arranged inside—of the pattern first used at the Manchester Exhibition—stands in the centre of the stall, and carries six arcs.

Messrs. Crompton had a fair assortment of their well-known types of dynamos on the ground, and the electric crane was in position.

Woodhouse and Rawson United have a Kingdon alternator, and an electro-hydraulic rivetter was also in position. This consists of a multipolar motor, which is enclosed by an almost globular cast-iron shell, from the inside of which the magnets project towards the centre. The commutator is accessible from an opening at one end, and the current is conveyed by two brushes only, which are at an angle of 60deg. apart, there being six poles to the magnets. The motor operates a wheel which has a square screw-thread cut through its boss, in which fits one end of a plunger. This is kept from rotating, and passes through a gland into a water-filled space, from which issues the plunger, which ends in the rivetting punch.

Messrs. J. White and Co., of Glasgow, have a good assortment of Sir William Thomson's new standard balances. They also have an instrument (also Sir William's) for measuring up to 50,000 volts. Another interesting appliance on their stand is a voltapile; this has been in use at Messrs. White's factory for some time for calibrating multicellular voltmeters. It consists of 400 zinc-copper couples, of flat section, of inverted ∩ shape, supported by an insulating plate. The couples are mounted so as to leave only a small space between the zinc of one couple and the copper of another, the space between the two legs of a single couple being several times greater. Terminals are provided at the extremities of the series. When the pile is required for use the projecting zinc-copper legs are dipped into a bath of water, and when withdrawn a drop of water is retained between the opposed plates of adjacent pairs, so that a difference of potential of about 400 volts is produced. The pile is, of course, quickly polarised if any current is allowed to flow. A standard instrument is, of course, used in calibrating. Messrs. White also show an instrument arranged so that by a simple adjustment it can be made to read directly the number of lamps in use on a circuit, supposing them all to be similar and of the same candle-power. The wire-work was in position for the Edison-Swan Company's "screen of lamps."

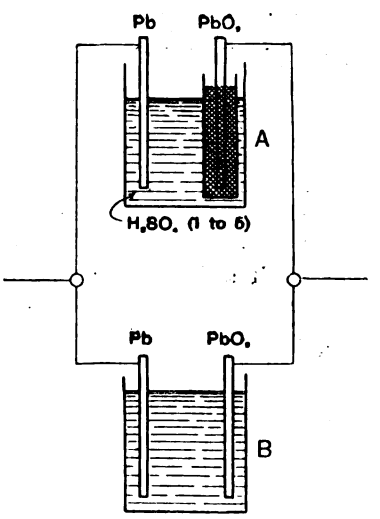
The Fowler-Waring Company, who are laying the mains from the Sydenham station to the Palace, have had considerable difficulty in drawing in their cables, owing to the manner in which the pipes have been laid, and it is to be sincerely hoped that no damage has resulted to the insulation. The pipes are of porcelain, of about 5in. bore, each pipe contains three cables, apparently of 19/15's. The insulating coating is about ·15in. thick, and the lead ·1in., the pressure being 1,000 volts continuous. We witnessed the joint-making; and both the insulating and plumbing were being carried out in a very thorough and workmanlike manner, as, indeed, might have been expected.

One interesting feature of the Exhibition will be the concert room of the National Telephone Company, where, on payment of a small admission fee, the public will have an opportunity of listening to the music performed at theatres in London, Birmingham, Manchester, and Liverpool.

SOME SECONDARY-BATTERY EXPERIMENTS.

A few days after the reading of his Society of Arts Paper (see *The Electrician*, December 4th, 11th, and 18th), Mr. Robertson was good enough to repeat for us the experiments with which he concluded his Paper; and, as they were not of a nature to be clearly seen by the majority of his audience, the following brief note may be of interest.

Cells A and B, which were of a diminutive description, were both charged from a battery of Daniell cells for about forty minutes. In A the peroxide and the lead plates were separated by a porous pot; in B there was no separation.



On taking the electromotive forces with a low-resistance twisted-strip voltmeter, that of A was found to be low (about 1·3 volt), while that of B was a trifle higher, but neither would give a deflection for long. On interchanging the plates of A, the voltage fell but slightly, and this was followed by permanent running down. The acid of A was then tested by the addition of potassium iodide, using starch as an indicator, and "active oxygen" was found to be present at *both* plates, accounting for the low electromotive force and the small effect of interchanging the plates. Acid was next taken from B, and poured on to some pure lead peroxide; there was no immediate evolution of oxygen, but after a time it was slowly liberated, proving the formation of *hydrogen dioxide* (H_2O_2) in the electrolysed acid, since persulphuric acid ($H_2S_2O_8$) does not affect peroxide of lead. A little hydrogen dioxide was then added to the acid of B, and caused a slight initial rise of E.M.F. followed by a permanent fall. Testing the acid used for making up the cells it was found to give no blue with potassium iodide and starch, showing plainly that it is the electrolysis of the acid which gives rise to the hydrogen dioxide.

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The plates of A were now taken out, and placed in an otherwise entirely fresh cell and charged for a short time. The electromotive force was about 1·7 volt, and interchanging the plates reduced it to zero. The plates were then restored to their original relative positions, a fresh lead plate being used. The electromotive force immediately rose, showing that the previous fall had been caused solely by the action of the acid on the *lead* plate. Transposing the plates again reduced the electromotive force to zero.

This cell, C, was now tested to discover the distribution of the "active oxygen"; and the acid next the lead plate when the plate was placed so that the electromotive force of the cell was high, was practically free from it.

These simple little experiments, which anyone who possesses a few Daniell and miniature storage cells, and some chemicals and test tubes can repeat for himself, may be taken as tolerably conclusive bases for Mr. Robertson's three main theses. (i.) With H_2O_2 generally distributed in a cell we shall have low electromotive force. (ii.) With H_2O_2 concentrated around the peroxide plate, we shall have high electromotive force. (iii.) With H_2O_2 concentrated around the lead plate, we shall have next to no electromotive force. Persulphuric acid is the primary product of the electrolysis of sulphuric acid, and, being unstable, begins to break up the moment the charging current is stopped, and combining with the electrolyte forms hydrogen dioxide, which gets gradually diffused through the cell, oxidising the lead plate to litharge and reducing the peroxide plate to the same substance, the litharge so formed being finally converted into sulphate by the sulphuric acid. A cell containing electrolysed acid, and left at rest for a long period at a time, is evidently, therefore, on the road to ruin unless treated with some such catalytic agent as Mr. Barbey Starkey's sodium carbonate.

THE PARSONS STEAM TURBINE DYNAMO,

The following report, by Prof. J. A. Ewing, of some trials of a 100-unit Parsons steam turbine dynamo at Heaton Works, Newcastle-on-Tyne, was submitted at an inquiry held by the Local Government Board on December 30, 1891, with regard to proposals of the Corporation of Cambridge to adopt a scheme of electric lighting:—

The machine tested is, I am informed, the first condensing steam turbine that Mr. Parsons has built. Its shaft was designed to carry six small and one large plate or disc, each fitted with a series of rings of turbine blades, the large plate being specially designed to deal with low-pressure steam. After passing it, the steam was exhausted into a jet condenser of novel design, the pump of which was driven by a separate donkey engine. The turbine rings were of the outward flow type.

The turbine was designed to work with steam at an initial pressure of 140lb. per square inch, but on the occasion of the trials it was not practicable, for want of a suitable boiler, to use a pressure of more than 95lb. per square inch. The first and second plates, with their turbine blades, were accordingly removed, and the tests were made with the remaining four small and one large plate. The effect of this was to make the results of the trials less favourable, as to economy in steam consumption, than they would have been had the full initial pressure of 140lb. been available.

In line with the turbine shaft, and directly coupled to it, was the armature of an alternate-current dynamo capable of yielding 100 kilowatts, or 100 Board of Trade units of electrical energy per hour, and wound for a potential of 2,000 volts. The exciter was a distinct small dynamo of the continuous-current Gramme type, which was also mounted on a prolongation of the turbine shaft.

The turbine ran at a speed of about 4,800 revolutions per minute, and the armature was wound with a single coil, so that the frequency of the alternations was about 80 complete periods per second.

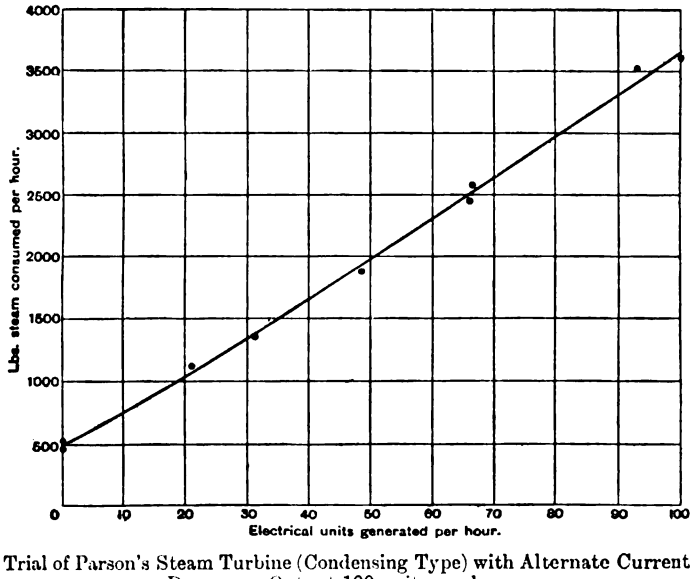
The whole machine, comprising the turbine, dynamo, and exciter, weighed about four tons; its length was about 14ft., and its greatest breadth barely 3ft. It stood on three cast-iron pedestals resting on an ordinary concrete floor. There were no holding-down bolts or special foundations, and none seemed to be required. The machine ran almost without vibration.

In the trials the current generated was spent on a bank of resistance coils consisting of open spirals of iron wire strung on wooden frames. The output was varied, in successive trials, from about 20 units per hour, or, say, one-fifth load, to 100 units per hour or full load. The loads spoken of are the amounts of electrical power spent in the external circuit, and do not include the work done by the exciter in supplying current to the field-magnets of the main dynamo. (The output of the exciter was about 2½ units per hour.)

In two additional trials there was no external load beyond what was necessary for measuring the potential.

The experiments were arranged to give complete information of the amount of steam used by the turbine under all grades of output, from full load to zero.

The electrical output was taken to be the product of the effective volts at the dynamo terminals into the effective amperes. The volts were measured by aid of a 2-H.P. transformer, which transformed down in the ratio of 1 to 10, and a pair of Cardew voltmeters. To test the accuracy of the professed ratio of transformation, the volts were on one occasion read by applying a Cardew voltmeter to successive portions of the bank of resistance coils (then grouped in series) so that the potential was directly determined by summing up the readings. This determination was found to agree exactly with that obtained by means of the transformer.



Trial of Parson's Steam Turbine (Condensing Type) with Alternate Current Dynamo. Output 100 units per hour.

The Cardew voltmeters were themselves tested by comparison with a third Cardew, which in its turn had been standardised by help of one of Sir William Thomson's balances. They were found to be correct.

The current was measured by (1) an Evershed gravity ampere-meter, and (2) a Siemens electro-dynamometer. These were connected in series in several of the trials, and were found to be in perfect agreement. The Evershed instrument had been tested against a Thomson balance.

The consumption of steam in the turbine was measured by passing the feed-water through a measuring tank, the capacity of which I checked. Steam was supplied from an old boiler of the locomotive type, at a pressure of 90lb. to 95lb. per square inch. The steam-pipe was too small, and the loss of pressure between the boiler and the turbine must have been considerable, especially in the full-power trials.

In the full-power trials this boiler was insufficient to supply all the steam, and another boiler was joined to it. It was then impracticable to measure the feed, and the amount of steam passing through the turbine was estimated in these trials by measuring the rise in temperature of the water discharged from the condenser, in conjunction with the amount of the water, as gauged by means of a weir. This rise in temperature

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and the head over the weir were noted in all the trials, so that when the feed was directly measured a constant was determined which could be applied in cases where a direct measurement of the feed was impracticable.

The boiler was old and leaky, but the amount of water which fell to be deducted from the whole feed on this account was repeatedly determined. The allowances made for leakage are certainly not excessive, and do not in any case affect the full-power trials materially.

The steam required for (1) the feed-pump, (2) the air-pump was supplied by a separate boiler, and is not included in the quantities that are stated below.

The vacuum ranged from 28½in., at light loads, to 26½in. at full load. The temperature of the cold well varied from 5°C. to 18°C.

The trials extended over three days—December 12th, 14th, and 15th, 1891. The turbine was kept running, without change of load, long enough in each case to secure a uniform *régime*, and to prevent any material error from being caused by an inexact reading of the water-gauge glass on the boiler. The machine ran without any hitch, throughout all the trials.

The following are the observed results. The trials distinguished by an asterisk are those in which the consumption of steam was inferred from the rise of temperature in the injection water. In the other trials it was measured directly, as feed-water.

Electrical output in units generated per hour.	Steam used in the turbine in lbs. per hour.	Electrical output in units generated per hour.	Steam used in the turbine in lbs. per hour.
0·3	510 } 492	65·9	2,460*
0·3	475 } (mean)	66·5	2,580
20·8	1,120	93	3,530*
31·2	1,350	100	3,600*
48·5	1,875		

These results are also shown graphically in the accompanying curve, which shows the relation of the number of lbs. of steam used by the turbine per hour to the number of electrical units generated per hour.

It is convenient also to express the results in another way, by stating the number of lbs. of steam used per unit generated, at various rates of output from full load downwards. These quantities, obtained by measurement from the curve, are given in the following table :—

Output in units per hour.	Number of lbs. of steam used per unit.	Output in units per hour.	Number of lbs. of steam used per unit.
10	77½	60	38
20	53	70	37½
30	45	80	37
40	41	90	37
50	39	100	37

It will be seen from these figures that the consumption of steam by this condensing turbine was 37lb. per electrical unit generated, when the machine was giving its greatest output; that the output might be reduced to, say, three-fourths of its greatest value without causing any sensible addition in the consumption of steam per unit; and that at half-load the consumption was 39lb. per unit. When the load is further reduced the consumption per unit increases, as it does in all engines, on account of the work which is expended within the machine itself.

The consumption of 37lb. per unit at full load corresponds to 27·6lb. per electrical horse-power per hour; and the consumption of 39lb. per unit, at half-loads, corresponds to 29lb. per electrical horse-power per hour.

For the sake of comparison it may be added that in a good ordinary compound condensing engine of corresponding power the consumption of steam is usually about 20lb. per *indicated* horse-power per hour, which corresponds (allowing for necessary loss in transmission to the dynamo) to, say, 36lb. per unit. In the special type of single-acting high-speed engines made by Mr. Willans and successfully used in many electric light stations the consumption of steam at full load and at moderately full load is somewhat less. The best results in trials published by him show (with high-pressure and triple expansion) a consumption equivalent to about 30½lb. per unit in a non-condensing engine, and 25lb. per unit in a condensing engine, worked at full load; while at half-load the numbers are about 43lb. per unit and 32lb. per unit respectively.

I have no doubt that if it had been practicable in the turbine tests to use the full pressure of 140lb. per square inch for which the turbine was designed (in place of a pressure of 95lb.) that the consumption of steam per unit would have been considerably reduced.

As they stand, however, the results must be admitted to demonstrate a very remarkable performance. They show that in respect of economy of steam, and therefore of fuel, at full or moderately full load the Parsons' Turbine of the type and size tested now challenges comparison with good engines of the usual kind, while its comparative freedom from friction gives it an exceptionally high efficiency when lightly loaded.

Apart from the question of steam economy, the lightness and compactness of the turbine-dynamo, its small first cost, the perfect ease with which it is started, its freedom from vibration, and the absence of any need for heavy foundations, are points much in its favour of a generator for central-station work.

Mr. Parsons has been good enough to give me every facility for examining the construction of his turbines and dynamos. I see no reason to anticipate that the charges for maintenance, for oil, and for attendance will be larger than in the case of other engines. I should rather expect them to be lighter; and this appears to be borne out by the experience of the Newcastle and District Electric Lighting Company, where turbine generators have been in use for about two years.

I had the advantage of seeing the plant at that Company's station and of obtaining particulars in regard to wages and other items of current outlay from the Superintending Engineer and the Secretary of the Company, who were most willing to supply information.

In regard to first cost, the turbine generator is probably cheaper, in large sizes, than any combination of ordinary engine and dynamo giving equal output. Mr. Parsons quoted to me the following prices for condensing turbines with dynamos, of either the alternating or continuous-current type. The cost of the condensing plant is not included :—

50-unit, £600; 100-unit, £850; 200-unit, £1,300.

The machine tested had an electrical governor which regulated by causing intermittent admission of steam. The action of this governor was not entirely satisfactory, and Mr. Parsons informed me that he meant to substitute for it a modified form of a type of governor which has been found to work well at the Newcastle and District Electric Light Station and elsewhere.

The turbine worked at its full load of 100 electrical units per hour without any sign of distress, and so far as could be judged was capable of giving a greater output without difficulty. The dynamo armature became hotter than is, in my opinion, desirable. This might be avoided by an alteration in the winding of the armature.

With a dynamo wound to give continuous-currents, the consumption of steam in the turbine per electrical unit generated may be confidently expected not to exceed the consumption observed in these experiments.

THE CAUSTIC SODA AND CHLORINE ELECTROLYTIC PROCESS.

Some time since we criticised the prospectus and patent of the syndicate whose name forms the heading of this article, and pointed out what we considered were weak points in the process and loose statements in the prospectus and the report which accompanied it. The process is now being brought into more tangible form, and an experimental plant of fair size has been set up at the works of Messrs. Bowes, Scott, and Western,

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at Battersea. The principle of the process, like that of many of its predecessors, is the splitting up of a solution of common salt with the production of caustic soda and chlorine by electrolysis, the details for which it claims originality being chiefly those relating to the construction of the anode and porous diaphragm. The experimental plant consists of a set of five tanks, Fig. 1, each with five cells, Fig. 2, with arrangements for circulating the liquor to be decomposed through all the anode and all the kathode cells, the former being of course provided with

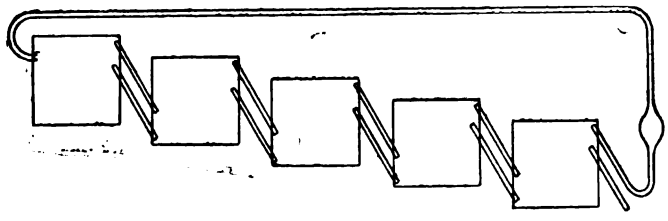

FIG. 1.—Set of Five Tanks.

means for conveying off chlorine and leading it to vessels of the ordinary type for making bleaching liquor or bleaching powder. The diaphragm, as will be seen in Fig. 3, is built up of a number of troughs of glass or slate set in ozokerit, the spaces between them being packed with asbestos. It will be remembered that much was expected of this diaphragm in the early days of the process, and it is true that if it fulfils the claims made for it it will add considerably to the perfection with which the chlorine can

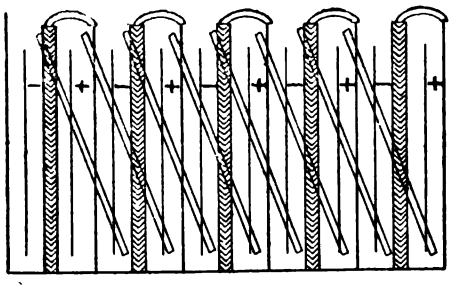

FIG. 2.—Tank consisting of Five Cells, separated by Diaphragms.

be kept out of the kathode cell without at the same time giving rise to much resistance. We may here remark that further information as to the exact resistance of this diaphragm is very desirable. The total resistance of each cell is stated, in the terms to which we objected in our previous article,* as about "5 volts"; but how much of this is due to the resistance of the diaphragm, how much to that of the solution, and how much must be credited to the expenditure of energy necessary to produce caustic soda, hydrogen, and

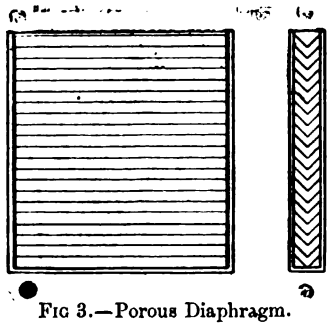

FIG 3.—Porous Diaphragm.

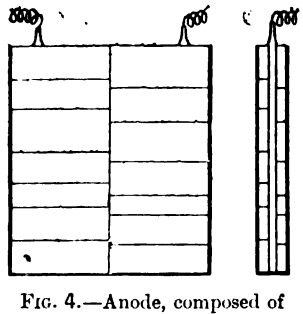

FIG. 4.—Anode, composed of Carbon and Type-Metal.

chlorine from sodium chloride, is left undetermined. With regard to the anode, which we also illustrate, Fig. 4, it consists of plates of retort carbon supported by a core of type metal, connection between the two being established by coppering and tinning the plates before the type metal is cast. It is found that only hard carbon of this description will stand the action of the chlorine; the plates are rendered non-porous by saturation with paraffin wax. They certainly appear well designed for their purpose, and it is stated that they suffer no appreciable deterioration. Turning from the plant to the process itself, it appears that the strength of the salt solution employed may be varied according to the use to which the caustic lye is to be put. Paper makers using 3 per cent. lye and indifferent to the presence of salt, may work with a brine of about 5 per cent. strength, and make no attempt to concentrate the product. If, however, solid caustic soda be required, brine about half saturated may be used with advantage, the caustic liquor boiled down when it reaches a moderate strength, and the salt fished out during evaporation. It is said that owing to the novel diaphragm very little sodium hypochlorite is formed; it is also stated that the chlorine comes away almost perfectly pure, and causes no spurting of the liquor during its evolution. It must be remembered that if the diaphragm is to be efficient the chlorine must encounter no resistance during its passage through the absorbing vessels, and this is provided for by a little exhausting fan capable of lowering the pressure within them sufficiently. At present no attempt is being made to utilise the hydrogen which makes its appearance at the kathode; this means a good deal of waste energy, and appears to have been somewhat overlooked up to the present.

The reports which have been given on the process by sundry experts go to show that an important saving in the cost of caustic soda and bleaching powder should be effected if the calculations on which the estimate is based are verified by the results obtained when working on a large scale. According to our view, the weak point in this, as in other electrolytic processes, is due to the fact that the output is small and slow when considered in relation to the bulky and expensive plant; so that interest on capital thus sunk becomes an item of extreme importance, even should costly repairs be avoided.

Whatever the upshot of the present attempt may be, it has at least been made on a fair scale and with well-designed and workmanlike plant. Power for the whole is supplied by an Elwell-Parker dynamo, capable of an output of about 350 amperes at 22 volts.

EXTENSION OF LOW-PRESSURE NETWORKS.

An interesting little article is contributed by Mr. W. S. Barstow to the *Electrical Engineer* of New York of December 16, 1891, in which he treats of a problem which will some day assume as much importance in London as it has already done in Brooklyn.

"Electric light companies," says Mr. Barstow, "in order to prove that the claim of 'light and power for the public' is justified, find it necessary to enter residential districts, and supply current on the same basis as gas. It is an unfortunate undertaking," he goes on to say, "for any dividend-earning company to erect and endeavour to maintain a central station in a residence district with the expectation of net earnings therefrom during the first or second year. The business man is willing to pay for commercial lighting a sum which he would never think of paying for the lighting of his residence. He will, however, instal 10 lights in his dwelling to one in his place of business, although he may only use one out of the 10. Thus, the lights burning in a residence district are only a small percentage of the lamps installed. The maximum load of a station in a residence district is actually about 25 per cent. of the lamps installed or connected, while that of a station situated in a business section of a city is never less than 50 per cent. This means, that in a residence district we must connect twice as many lights as in a business district to get the same income. Another unfortunate thing in residence lighting is the fact that during four months of the year the dwellings are closed, and during the months they are occupied the light is only used about five hours out of the 24. The fact that current can be supplied more economically from a station already in paying operation than from a station having heavy operating expenses to start with, needs no emphasis, as current generated in quantity with large units working efficiently is more economical than current generated in a number of small units. Thus it only remains to be ascertained

* *The Electrician*, Vol. XXVII., p. 193.

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what we can afford to lose in conductors. And in order that this point may not be considered entirely theoretically, it might be of value to those interested in this subject to know what has been actually done in this direction from a practical standpoint.

"The second district system of Brooklyn is laid out similar to any ordinary Edison three-wire central-station system of underground conductors; each feeder is brought to a central point of distribution situated on land owned by the company, so that in the event of the load warranting the operating of a station in after years no change in the feeders will be caused by its erection. From this central point of distribution a large feeder is laid to the first district station, a distance of about two miles. The question arose before the work was begun: At what load would the economy of transmission on this feeder be overbalanced by the loss in the conductors and interest on

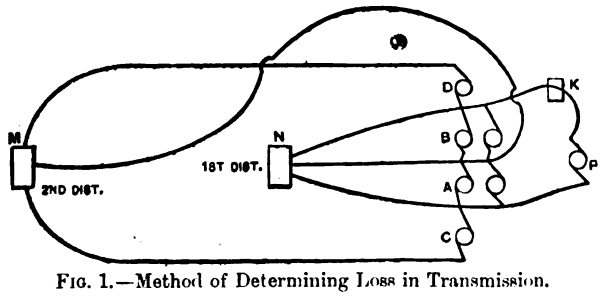

FIG. 1.—Method of Determining Loss in Transmission.

any special apparatus required? To answer this question, the cost of labour, interest on investment, and deterioration of a new isolated station must be balanced against increased cost of labour in old station, interest on investment, deterioration, and the loss in transmission—the cost of fuel, water, &c., remaining the same in either case."

Mr. Barstow then proceeds to show that the problem practically reduces itself to the equation $L - l = \lambda$; where L is the cost of labour per diem at a *new* station, l the increased cost of it at the old station, and λ is the cost per diem of the power lost in the feeder. In the case in question $L - l$ comes out at 42s.

The following plan, similar to the one used by Lahmeyer at Rostock, and alluded to at the time in our editorial columns (*The Electrician*, Vol. XXII., p. 581), was adopted by Mr. Barstow, and has been in successful operation at Brooklyn for the past twelve months.

"In the diagram Fig. 1, M and N denote the centres of distribution of the two districts, in which N is practically the location of one station, and M is about two miles distant from this point. A and B are the two pairs of machines (more or less) on ordinary three-wire system, supplying current at 115 volts to N. To supply current to M (at the same voltage at lamps), dynamos C and D are placed as shown in the diagram. The armatures of these machines C and D are wound for the maximum current supplied to M, the voltage being the maximum economical drop in transmission in feeder. These two machines are belted to a 230-volt motor, P, which is run from the main station bus. As may be seen in Fig. 1, C and D will generate whatever watts are lost in transmission in conductor to M, the watts furnished to the lamp at M being generated at A and B. In fact, in action, C and D are nothing more than electrical (hydraulic) rams raising the pressure of the current delivered by A and B. By making C D series machines they become entirely automatic in regard to the regulation of the pressure necessary to counterbalance the drop in the feeder. In the motor circuit a meter is placed at K, and this gives us the total loss in transmission + the inefficiency of the transforming device, and by subtracting the latter from the total reading the actual loss in the conductor may be obtained. In transmitting 300 amperes to M, the average day load in the residence district, the pressure of C or D is 10 volts."

With this arrangement the average value of λ per diem came out at 13s. 6d., which leaves a margin of about £500 per annum in favour of the long-feeder plan.

"By calculation of total number of lamp-hours (of 8,000 lamps connected) and receipts, the cost per lamp hour at the centre of distribution in the new district two miles from the generating centre is 10 per cent. more than at the generating centre. The above figures need no explanation as to the financial efficiency of low-tension transmission. Of the 8,000 lamps connected 5,000 are located 2,500ft. from the distributing point of this district, or about two and a-half miles from the generating point; 1,000 lamps and 60 H.P. in motors are connected 5,000ft. from the distributing point, or three miles from the generating point!

"Fig. 2 is a diagram of an average daily pressure at the main station-end of the transmitting feeder. The constant for this diagram is 7·82 amperes = 1 volt drop (each volt above 117). This gives one-half the load of the feeder at 117 volts. In the manner above shown, new districts may be entered without serious loss in earnings, and whenever the district becomes so loaded as to pass the point of economy by transmission, a station can be erected which from the very start will have a good paying load. The feeder may then be turned into new territory, or left as a tie-line between the two stations. The advantages of this system for residence lighting will be appreciated by all companies who have struggled along, turning over the net earnings of one station to make good the deficit of another."

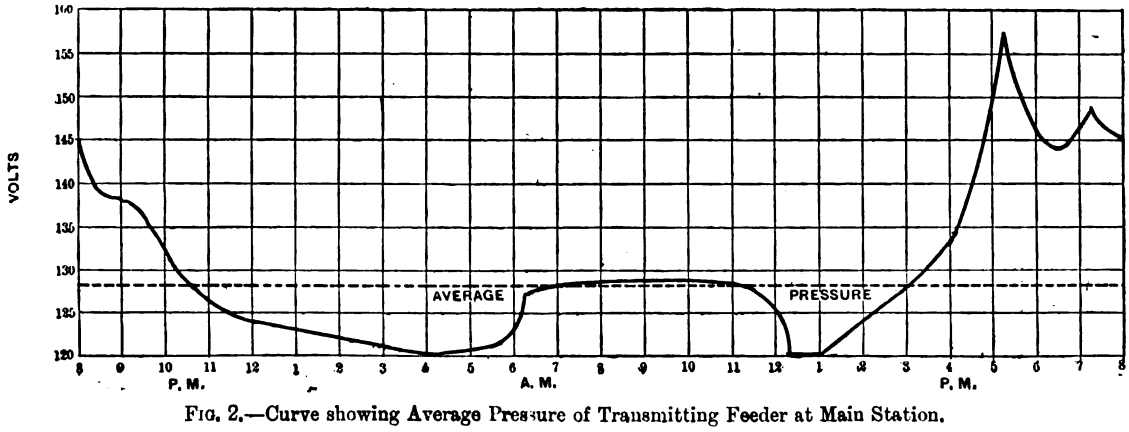

FIG. 2.—Curve showing Average Pressure of Transmitting Feeder at Main Station.

A TELEPHONE TRANSMITTER WITHOUT ELECTRODES.*

BY CHARLES CUTTRISS.

While it would appear that the field of telephone transmitters had been pretty thoroughly gleaned, still among the stubble there has remained one that promises to be of considerable importance both for long and short distance transmission. As is often the case, the present invention is the result of research in a new direction. Upwards of a year ago I was experimenting with some carbon contact points,

* From *The Electrical Engineer* of New York.

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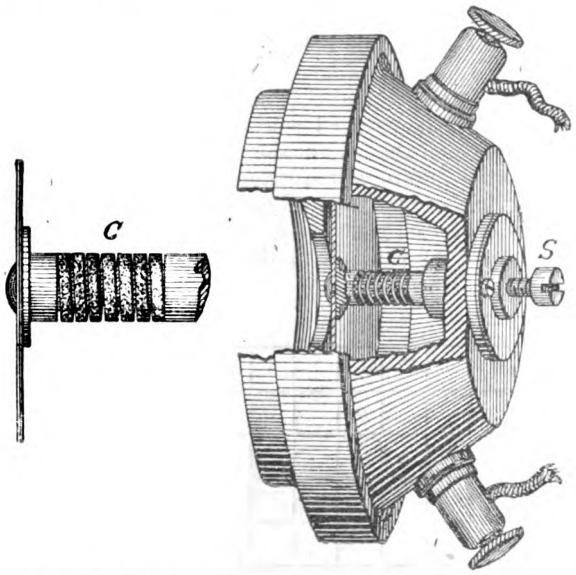
with a view to getting data of their action under different pressures and with various strengths of current. In one set of experiments I was surprised to observe a steady movement of the galvanometer, indicating a gradual increase of resistance in the circuit; and, as the opposite effect was expected, I was led to examine closely into the cause of this action. Arranging the contact points in such a manner that they could be examined by a powerful magnifying glass, it was observed that on the first application of the battery there was a good surface contact between the carbons, but that as they expanded under the heat the surface gradually became raised until, at last, the contact was so exceedingly small that it became incandescent for an instant. At the moment of incandescence the contact points fell together again, and the action was repeated, the whole cycle taking about 30 seconds, and in some cases it would keep on repeating with great regularity for 20 minutes, or more, before the points became so much changed as to stop the action. While it was interesting to observe this action, it was, on the other hand, very disappointing, as it showed the impossibility of using the contacts for the purpose intended.

I was then led to try a number of contact discs, but here I was met by the difficulty that with the light pressure I was using—only from 2 to 10 grains—the various discs would never resume their former condition after the removal of the pressure. It was at this time that I realised that the only



Figs. 1 and 2.—Cuttriss' Telephone Transmitter without Electrodes.

way to get around the two difficulties would be to make such an arrangement that each contact should have a tendency to spring open, and at the same time preserve continuity of circuit. After trying numerous devices without success it occurred to me that a helical carbon spring, if such a thing could be made, would offer the best solution of the difficulty.

For upwards of a month I had a maker of incandescent lamps trying to produce some of these helices, but without success. I then determined to try it myself; so, with an Edison fan motor geared direct to a fan rigged up out of a tin can, an improvised Fletcher's blow-pipe, and a small circular crucible furnace, I went to work, and in a few hours had got my first helix. But, as may be imagined, it was too ethereal for the rough and tumble of this world.

Nevertheless, it showed that I was on the right track, and after a few days' practice little trouble was experienced in turning out about anything I desired. I now have the carbon helices of such resistances that when closed in their natural condition they have a resistance of about 10 ohms; but when fully distended the resistance is upwards of 500 ohms, and a movement of ·01 of an inch tending to open the convolutions makes a variation of from 100 to 200 ohms. Their action on the instrument for which they were designed was perfect, and no sparking could be observed between the convolutions until the battery was increased to such an extent that the whole helix was heated to some 300 or 400 degrees Fahrenheit.

This absence of sparking under heavy battery at once struck me as a valuable feature in a telephone transmitter; and as the battery circuit could never, under any circumstances, be interrupted, there should be an absence of those ear-breaking kicks which are so often experienced when impatience is expressed at the distant end.

As a result I devised the simple arrangement shown in the accompanying engravings. As will be noted in Fig. 1, the helical carbon spring C is permanently cemented to the diaphragm and presses against the end of a screw, S, to which it is also permanently connected and by which its tension can be regulated and the convolutions of the helix brought nearer together, or separated, as desired. The carbon helix is shown enlarged in Fig. 2.

Experiments proved the correctness of my theory, and not only does the instrument transmit speech loudly, but the enunciation is so remarkably clear that I have been led to look for some particular reason why this should be so. I think it will be found to be owing to the extreme lightness of the helix (generally less than one grain); to the absolute continuity of the circuit—that is to say, the elimination of electrodes; and also to the fact that as each part of the spiral is tending to open itself it absolutely precludes any tendency for the surfaces to jam or lock together.

DAMPING OF ELECTRICAL OSCILLATIONS ON IRON WIRES.*

BY JOHN TROWBRIDGE.

It has generally been assumed by those who have studied the subject of very rapid oscillations of electricity, such as occur in Leyden-jar discharges, that the magnetic character of the conductor has very little influence on the nature of the discharge. The early investigations of Hertz seemed to show that for such oscillations the self-induction of the electric circuit depended only on the size and shape of the conductors, being independent of the material; and the analogous researches of Dr. Lodge appeared also to point to this conclusion.

Although the impulsive impedance is apparently not affected by the magnetic character of the wire, our experiments lead us to believe that discharges of the quick period of a Leyden jar are affected very appreciably by the magnetic nature of iron, steel, and nickel conductors. This effect is so great that it damps the electrical oscillations, and makes it difficult to determine whether the time of oscillation is also affected by the permeability of the conductor.

The apparatus employed was similar to that described in my investigations of electrical oscillations with an air condenser (*Proc.* American Academy of Arts and Sciences, May 28, 1890). Certain important modifications, however, were made. The plane mirror which I used in the former research was replaced by a concave mirror of 10ft. focus and 3½in. in radius. This mirror was mounted upon the end of the armature shaft of a one-half horse-power electric motor.

The discharging apparatus consisted of a sharp-cutting tool, insulated, and mounted on the edge of the rotating disc bearing the mirror. It was metallically connected with a grooved ring of brass mounted upon the shaft and insulated from it by hard rubber Around this was wound a copper wire, one end of which was connected with the discharging wire and the other drawn taut by a rubber band. The electrical discharge was thrown upon the circuit by pushing forward a lever, which brought a solid hinged frame containing a strip of soft type-metal into contact with the rapidly revolving steel cutting tool. An electrical contact was thus insured by the tool cutting a groove in the strip of type-metal. In order to avoid a spark at the contact the type-metal was thickly covered with a wax of peculiar composition. The only spark, therefore, that occurred was the one the oscillations of which I desire to study. At each trial the type-metal was moved so as to expose a new cutting surface. The type-metal was insulated from the rest of the apparatus, but connected with the outer coating of the Leyden jar. First, both terminals of the Holtz machine were thrown off, and immediately after, the cutting tool, ploughing its way through the type-metal, placed the outer coating of the Leyden jar in circuit with one of the two parallel wires leading to the terminals of the spark. The other wire was permanently in connection with the inner coating of the jar.

Besides the short lead wires above described, the discharging circuit consisted of two parallel wires 30 centimetres apart and

* From the *Phil. Mag.*, December, 1891.

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510 centimetres long. These were the only portions of the apparatus changed during the experiment, and they were replaced by wires of different material and of different size. The other conditions—length of spark, lead wires, and the copper cross-wire connecting the outer ends of the long parallel wires—remained undisturbed throughout the experiment.

The Leyden jar was charged each time as nearly as possible to the same potential, judging by the number of turns given the Holtz machine. It is unfortunate that no more accurate means of measuring it were at hand, although the different negatives showed but slight variation. The capacity of the jar with alternations of this period was 5,060 electrostatic units.

I describe the discharging portion of the apparatus minutely, for the success of an investigation of this nature depends upon the suppression of all sparks save that which one wishes to observe, and my method surely and completely accomplished this. The photograph of the spark could thus be made to fall very accurately on the sensitive plate. When one considers that the image of the spark was flying through the air on a circle of ten-feet radius with a velocity of a mile a second, it will be seen that an extremely small deviation in the point of contact between the cutting-tool and the type-metal would have thrown the image entirely off the sensitive plate. A singular phenomenon was noticed in this connection. When a comparatively low potential was used, such as that afforded by the air-condenser used in our previous investigation, the cutting-tool ploughed two or three millimetres along the surface of the type-metal before a spark passed at the point in the circuit where it was desired. With higher potentials this phenomenon was also observed, but the extent of cutting was diminished. It is possible that the insulating wax may have melted under the sudden blow of the cutting-tool, and, flowing around it, prevented instant contact. This seems to me improbable, for a deep and clear-cut groove was made in the soft type-metal. Great attention was paid to the solid structure of this contact apparatus. It was entirely separate from the support of the revolving parts, and was perfectly steady.

The other end of the armature-shaft was lengthened into a cylindrical chronograph, similar to that described in the article already cited, and its performance left nothing to be desired. A small Ruhmkorf coil excited by two storage cells, and interrupted by a seconds pendulum, gave a record of the speed of the mirror. The stylus which drew the spiral turns on the barrel of the chronograph was drawn along the barrel by means of a small heavily loaded carriage, which, on being released at the moment the lever arm threw the type-metal in contact with the cutting-tool, descended an inclined plane of adjustable height. A small Toepler Holtz machine charged a large Leyden jar, and it was found to work admirably in all states of the weather.

The apparatus which I have thus described was the result of the experiments of the previous year, and worked for months without failure; and the taking of photographs of the oscillating discharge by it became a mere matter of routine.

The following cases were tried :—

1. When the long parallel wires were of copper (diameter ·087 centimetre), the number of double oscillations visible on the negatives averaged quite uniformly 9 or 9·5.

2. Where the wires were of German silver (diameter ·061 centimetre), 3 oscillations were visible.

3. But when an annealed iron wire (diameter ·087 centimetre) was substituted, only the first return oscillation was distinctly visible, with occasionally a trace of the first duplicate discharge.

4. On substituting fine copper wire (diameter ·027 centimetre), 5 complete oscillations were quite uniformly visible.

5. Fine German silver wire (·029 centimetre), nickel wire (·019 centimetre),* soft iron (·027 centimetre), and piano steel wire (·027 centimetre), gave but faintly the first return discharge after the pilot spark.

The pilot sparks were in all cases strong.

The single return discharge through the iron wire did not admit of measurement sufficiently accurate to furnish any basis for calculation of self-induction. The time did not apparently differ, if at all, by more than 14 or 15 per cent. Some general reasoning based upon the number of oscillations may be of interest. It must be acknowledged, however, that this reasoning is open to criticism, although it affords the most plausible explanation of the phenomenon. The phenomenon itself is not a doubtful one.

The time of a double oscillation for the large-sized copper wire was ·0000020 second, for the small copper wire ·0000021 second. The others, as far as could be determined, did not differ much from these values, and for this purpose either value is sufficiently accurate. Denote by R′ the ohmic resistance of the parallel wires to alternating currents of this periodicity, by R the resistance to steady currents.

$$p = 2\pi/t = 3{,}000{,}000 \text{ (practically).}$$

* Obtained by the kindness of Joseph Wharton, Esq., of Philadelphia,

Taking the cases up in order :—

1. Large copper wire,

$$R = \cdot 285 \times 10^9,$$

and substituting in Lord Raleigh's formula

$$R' = \sqrt{\tfrac{1}{2} p l \mu R},$$

$$R' = \cdot 66 \times 10^9.$$

2. Large German silver wire,

$$R = 9 \cdot 21 \times 10^9,$$

and substituting in the series

$$R' = R\left(1 + \frac{1}{12}\frac{p^2 l^2 \mu^2}{R^2} - \frac{1}{180}\frac{p^4 l^4 \mu^4}{R^4} + \ldots\right),$$

$$R' = 9 \cdot 2 \times 9.$$

3. Large iron wire,

$$R = 2 \cdot 5 \times 10^9,$$

and if there is a true time lag, as often stated, such as to prevent action of the magnetic property of the iron, and if on this assumption we make $\mu = 1$,

$$R' = 2 \cdot 78 \times 10^9.$$

4. Fine copper,

$$R = 3 \cdot 3 \times 10^9,$$

$$R' = 3 \cdot 5 \times 10^9.$$

5. Again, as before, call $\mu = 1$ in iron, nickel, and steel.

The length of these circuits was 7·41 metres, the remainder of the 10·20 metres—2·79 metres—being of copper wire of R′ = ·94. The value of R′ in the separate cases, including in each the resistance ·94 of the copper portion, was as follows :—

Soft iron..... $15 \cdot 0 \times 10^9$,
Piano-steel... $20 \cdot 7 \times 10^9$,
Nickel..... $30 \cdot 6 \times 10^9$,
German silver $23 \cdot 0 \times 10^9$.

The ratio of the strengths of successive discharges during the oscillation is given by the function

$$\epsilon^{r\,T/2\,L},$$

where r is the ohmic resistance, T the time of a double oscillation, and L the self-induction. The ratio of one discharge to the nth one after it is

$$\epsilon^{n\,rT/2L}.$$

If we assume—and it is a large assumption, but one which, perhaps, the result will in some measure justify—that the ratio of the strength of the first to the strength of the last visible discharge is more or less a constant, we may make use of the above data. Denote T/2 L by A, and call the unknown resistance of the short connecting lead wires and of the spark x. Then will $r = R' \times x$; n will be the number of complete oscillations visible.

Take cases (1) and (2), large copper and large German silver wires,

$$\epsilon^{n_1 (R'_1 + x) A} = \epsilon^{n_2 (R'_2 + x) A},$$

$$n_1 (R'_1 + x) = n_2 (R'_2 + x),$$

$$9 \cdot 5 (\cdot 66 + x) = 3 (9 \cdot 2 + x),$$

$$x = 3 \cdot 4 \text{ ohms.}$$

Taking cases (1) and (4), large copper and small copper, similarly,

$$n_1 (R'_1 + x) = n_4 (R'_4 + x),$$

$$9 \cdot 5 (\cdot 66 + x) = 5 (3 \cdot 5 + x),$$

$$x = 2 \cdot 6 \text{ ohms.}$$

Experiments with other copper wires having R′ equal to 3·4 and 1·27 gave 5 and 8 for the values of n respectively, or $x = 2 \cdot 4$ ohms.

The resistance (R′) of the lead wires forming part of x was ·8 ohm, leaving as a possible value for the resistance of the spark about 2 ohms.

If, taking this value of x, we calculate the value of R′ necessary to damp out the oscillation in one complete double discharge in the case of the large iron wire, we shall have

$$9 \cdot 5 (\cdot 66 + 3) = 1 (R' + 3),$$

$$R' = 30 \text{ ohms.}$$

But neglecting the magnetic property of the iron, its calculated resistance to alternating currents of this periodicity was R′ = 2·78 ohms. This is obviously inadequate, and would point to the conclusion that the oscillation is not, as sometimes stated, too rapid to admit of the magnetic action of the iron.

If we substitute this value R′ = 30 in the equation

$$R' = \sqrt{\tfrac{1}{2} p l \mu R},$$

we have for the resulting value of the magnetic permeability

$$\mu = 230.$$

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This lies between the limits $\mu = 103$ and $\mu = 1110$, found by taking the number of oscillations one and a-half and one-half respectively for the case of the iron wire.

It should be noticed that this estimate of μ necessitates assuming that T and L remain the same within broad limits. Measurements of the single oscillation on the negatives show that this is near enough the case. Part of the more rapid decay of the oscillation in the iron may be well ascribed to the dissipation of energy by hysteresis. While we cannot place much reliance upon an estimate of its value in such a case—its percentage effect probably increasing rapidly with the decay of the spark—it is not difficult to show that its influence may be very great.

There still remains the fact, not generally recognised, that in Leyden-jar discharges through iron wires the magnetic property of the iron has time very materially to modify the character of the spark.

I give an example of the measurement of the half oscillation, which was the only one visible on the photograph of the discharge over iron wires, all the others having been damped or extinguished by the iron, in comparison with the measurement of the similar half oscillation on copper wires of the same diameter as the iron wires. The number of oscillations on the copper wires was from eight to ten. The total duration of the discharge on iron wires was only three-millionths of a second, while that on similar copper wires was three hundred-thousandths of a second. A steel wire gave the same results as the annealed iron wires.

	Length of first half oscillation in millimetres.		Length of first half oscillation in millimetres.
Fine iron wire.	·23 ·21 ·19 — ·21	Large iron wire.	·20 ·20 ·19 — ·19
Fine copper wire.	·19 ·20 ·20 — ·19	Large copper wire.	·17 ·18 ·20 — ·18

I wish to express my deep obligations to my assistant, Mr. W. C. Sabine, for his valuable suggestions and for his skill in the mechanical details of this investigation.

Conclusions.

1. The magnetic permeability of iron wires exercises an important influence upon the decay of electrical oscillations of high frequency. This influence is so great that the oscillations may be reduced to a half oscillation on a circuit of suitable self-induction and capacity for producing them.

2. It is probable that the time of oscillation on iron wires may be changed. Since I have been able to obtain only a half oscillation on iron wires, I have not been able to state this law definitely.

3. Currents of high frequency, such as are produced in Leyden-jar discharges, therefore magnetise the iron.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

New York, *December* 24, 1891.

The Edison Electric Traction System.—At last an authoritative statement has come from the Edison General Electric Company regarding Mr. Edison's new plan for a street railway service, of which there has been so much talk. It proves to be precisely what my first mention of it to you indicated—his old plan of supplying a very low E.M.F. to the rails, furnishing the current to short independent sections of track by means of constant-current transformers operated at high tension from a central station. It is stated that the car motors are wound with uninsulated copper wire, and that the pressure is so low that the armatures themselves can be doused with water without the slightest ill effect. The Edison Company was presumably driven in self-defence to make this frank statement of the facts, because the reports that went the rounds were of such a character as to seriously hinder the development of the trolley system, in which the Edison Company, like others, is interested. The opinion of electrical engineers in general seems to be unfavourable to this plan, as, aside from its involving the reconstruction of all tracks, and a most elaborate system of bonding in order to carry these enormous currents, its efficiency is necessarily low on account of the extra transformation required and the inevitable leakage, which, although it would be only a few horse-power per mile, is still very objectionable.

The Trolley System in Brooklyn.—A great victory has been achieved for the trolley system in the city of Brooklyn, where the Board of Aldermen recently passed an ordinance permitting its use upon the surface roads. The Company that controls the street railways of Brooklyn has long been desirous of changing from horses to electricity, but until now they have been hindered by the difficulties in obtaining the necessary permission. Now, however, the work will probably be begun next spring, and carried on as rapidly as possible. The intention of the Company as regards the system of motors to be used has not been made public; there seems, however, to be a strong probability that the Thomson-Houston Electric Company, which furnished the equipment for the great West End system of Boston, will be looked on with special favour. Possibly, too, some one of the new gearless motors will be given a chance to show its merits. It is safe to say, though, that the bulk of the equipment will be single-reduction machines, as these seem to be now the general favourities, and have already proved their merit.

Proposed New Edison Station for Chicago.—It is rumoured that Chicago is to have an Edison central station of enormous capacity, quite eclipsing anything of the kind in the world; and it is even stated that the site has been selected for it. Chicago, in the compactness of the business district, is favourably situated for low-tension electric lighting, and the Edison Company has already made a good record.

Telephones.—The telephone interests have been pursuing their quiet way, quite undisturbed by the cyclone of patents that struck the business a few weeks since. The long-distance service in and about New York is constantly on the increase, and is, on the whole, unusually well conducted. It is the intention ere long to use double metallic circuits throughout the city.

CORRESPONDENCE.

WHAT IS ELECTRICITY?

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Will you allow me to point out what I consider a flaw in your ingenious answer to Mr. Gerald Molloy's analogy. It is quite true, as you say, that the *pounds*, in foot-pounds, do not represent mass, but *force*, and so are not analogous to *quantity* of electricity. But neither, on the other hand, do the *feet* correspond to volts. If, instead of comparing the formula $W = Q \times V$, with $W = M g \times h$, we compare it with $W = M \times g h$, the analogy is exact. Q corresponds with M, and V with g h, which latter is the difference of potential due to difference of level; whereas h is the difference of level itself.—Yours, &c.,

Wimbledon, Jan. 2, 1892. W. M. Madden.

P.S.—It does not follow that Mr. Molloy's analogy is conclusive. Analogies seldom prove anything; and when, as in this case, the definitions are founded on the analogy, it is clear that the latter can afford no extraneous support to the former.

THE ASSOCIATION FOR THE IMPROVEMENT OF GEOMETRICAL TEACHING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of December 4th appears an article by Mr. O. Heaviside in which, after advocating the use of vectors, the author mentions the Association for the Improvement of Geometrical Teaching, but states that he has no knowledge of its work. With your permission I will give a short sketch, in the present letter, of the *history* of the Association, and in a second one of *its present condition* and *its aims for the future*.

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The Association held its first annual meeting in January, 1871, with Dr. T. A. Hirst in the chair. In an able address, which still deserves the careful study of geometrical reformers, the President pointed out both the urgent need of reform and the great practical difficulties in the way of effectively carrying it out. Among the resolutions carried was the following important one, from which most of the subsequent work of the Association has sprung :—"*That all members be invited to furnish programmes, or suggestions relative to a programme, of the subjects which a text-book on Geometry ought to include.*" In response, eleven members sent in programmes. In these there was entire coincidence on eight important points, and great agreement on six others.* It was now felt that the Association could proceed with the formation of a Syllabus of Geometry, and a sub-committee was appointed with that object. After considerable communication of ideas between members of the Association and various eminent mathematicians, a Syllabus was drawn up and finally adopted by the Association at its fifth annual meeting (1875). This Syllabus was submitted to various important bodies, one of which, a committee appointed by the British Association *for the purpose of considering the possibility of improving the methods of instruction in Elementary Geometry*, and including among its members Profs. Cayley, Sylvester, H. J. Smith, Henrici, and Clifford, reported favourably on the "care and the regard to the essential conditions of the problem" with which it had been drawn up.

The next step was to publish a Text-Book ; for until that step had been taken the want of a suitable one was an ever ready answer on the part of obstructive examining boards when asked to give consideration to the work of the Association. The completion of the Text-Book in 1886 afforded a convenient occasion for memorialising the Universities ; and in answer to a numerously signed petition the Oxford Board of the Faculty of Natural Science reported as follows :—

"That a rigid adherence to the ordinary text-books of Euclid should no longer be insisted on, but that a greater freedom of demonstration should be allowed, both in Geometrical teaching and in Examination.

"That, nevertheless, Euclid's *method* should be required in all Pass Examinations in Geometry, in so far as that no axioms other than those of Euclid shall be admitted, and that no proof of a proposition be allowed which assumes the truth of any proposition which does not precede it according to Euclid's order."

This report was adopted by the Hebdomadal Council (June 20, 1887), and the report, to the same effect, of the Cambridge Special Board for Mathematics was adopted by the Senate, March 8, 1888.

The Council of the Association then addressed Her Majesty's Civil Service Commissioners, calling attention to the action of the Universities, and received a reply that they had "instructed their occasional examiners to make no deduction from the marks allotted to a question because a candidate substitutes another proof for Euclid's if this proof is a sound one and keeps to Euclid's sequence of propositions." As far as Geometry is concerned, though doubtless many improvements still remain to be effected in the methods of teaching it, the Association seems to have carried out the corporate aims with which it started, *as far as is desired by the greater part of those teachers who compose it.*

I hope to devote a second letter to its present condition and to the work that lies before it, merely drawing attention to the fact that in 1881, without altering its *name*, the Association extended its work so as to include all branches of Elementary Mathematics and Mathematical Physics.—Yours, &c.,

EDWARD M. LANGLEY, Hon. Sec. A.I.G.T.

16, Adelaide-square, Bedford.

*P.S.—The eight points on which there was entire agreement were :—

(*a*) That practical geometry should precede theoretical.

(*b*) That numerical examples should be introduced in illustration.

(*c*) That the axiom known as Playfair's respecting parallels, viz., "Two straight lines which intersect one another cannot both be parallel to a third straight line," should be substituted for Euclid's.

(*d*) That the notion of rotation should be introduced into the definition of an angle.

(*e*) That Euclid's treatment of regular figures in Book IV. is unsatisfactory.

(*f*) That the treatment of proportion for both commensurable and incommensurable quantities should be rigorous.

(*g*) That problems should be separated from theorems.

(*h*) That the conception of a Locus should be introduced.

The six points on which there was great, though not entire, agreement :—

(i) That it should be considered as an axiom that the shortest distance between any two points is the straight line joining them.

(ii) That the treatment of parallels should precede that of the comparison of triangles.

(iii) That the restriction of the term "angle" to such angles as are less than two right angles should not be maintained.

(iv) That the method of superposition should be more freely used than in Euclid.

(v) That in the treatment of a tangent the method of limits should be recognised from the outset.

(vi) That Euclid III., 35—37, should be proved by similar triangles.

PLATINOID v. COPPER FOR D'ARSONVAL GALVANOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : Replying to Mr. Crawley's letter on the above subject, published in your issue of December 18, 1891, I had no desire to debit him with hanging a 0·4-ohm coil with a 10-ohm suspension ; for I am well aware that he understands the subject too well not to utilise Prof. Ayrton and Perry's phosphor bronze strip in such a case. The comparison of a 10-ohm platinoid coil and a 0·4-ohm copper one was made merely to show that in cases where it is desirable to use instruments of comparatively low resistance (and these cases are of frequent occurrence), a comparison made on the lines he had chosen for the 500-ohm platinoid and the 20-ohm copper, viz, equal numbers of turns of the same gauge of wire, was by no means as favourable to copper as in the example he had chosen. The difference arises from the fact that the resistance of the suspension then becomes so important.

A better basis of comparison in such cases was then described (*see* §§ 6, 7, and 8 of my previous letter, *The Electrician*, p. 154), and to this I have nothing to add.

Mr. F. V. Andersen's letter calls for more detailed considerations.

First of all let me say that he evidently misunderstood Prof. Ayrton's remarks about the improvements introduced by the writer. The increased sensitiveness to which Prof. Ayrton referred is of the order 3 or 4, and not 20 times. On the other hand, an instrument, in designing which Prof. Ayrton and the writer are at present engaged, promises an increase of sensitiveness of between 100 and 200 times that of an ordinary d'Arsonval galvanometer.

Coming to the main point at issue, viz., whether it is desirable to replace the 420-ohm copper coil of his standard ammeter galvanometer with a 10-ohm platinoid one, Mr. Andersen pleads that the all platinoid instrument would be useless for the special purposes referred to in the Paper by Capt. Sankey and himself. On looking over that Paper the only purpose to which the instrument seems to be applied, other than as a shunt to the main ampere-rheostat, is to calibrate the standard voltmeter galvanometer. Here the "current galvanometer" is put in series with a Clarke's cell, and is used to indicate any want of balance between the E.M.F. of the cell and the potential difference at the terminals of rheostat A. According to the Paper the spot of the present instrument will move visibly for a ten-millionth of an ampere, and this corresponds

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to an error of 0·011 per cent. in the calibration of the voltmeter. If we now suppose the copper-wound coil replaced by the one wound with platinoid, the same movement would be caused by a current of

$$1/10 \times 21{\cdot}5 \times 4/5 \times 10^{-6} \text{ amperes,}$$

i.e., by 1·72 millionths of an ampere.

Since the resistance of the circuit would be 410 ohms less than when the copper coil was used, the percentage accuracy attainable with the platinoid coil would be

$$\frac{0{\cdot}011 \times 17{\cdot}2\,(1600 - 410)}{1600}$$

or 0·14 per cent., which is well within the 0·2 per cent. aimed at by the authors.

But I venture to think that the accuracy attainable with the copper coil has been considerably understated; for, from Table 2 of the Paper the ratio between the second and third constants (K) is 5 to 1; and since the accuracy attainable is $\frac{1}{5}$ per cent., a deflection of a fifth the length of the scale can be read to an accuracy of $\frac{1}{5}$ per cent. This corresponds to 0·44 scale division, and hence means a current of $0{\cdot}026 \times 10^{-6}$ amperes; therefore the accuracy attainable is 3·8 times that stated, consequently it would be possible to detect an error of 0·0029 per cent. ($\frac{1}{340}$ per cent.) with the copper coil. Making a corresponding correction for the platinoid coil, it would enable the balance to be kept within 0·037 per cent. ($\frac{1}{26}$ per cent.).

The above numbers show that the platinoid-wound instrument would be amply sensitive for calibrating the standard voltmeter; and, so far as this test is concerned, the substitution of a 10-ohm platinoid coil for the 420-ohm copper one would not necessitate an extra galvanometer being installed. Hence Mr. Andersen's "Disadvantage No. 1" does not exist.

It is no use calibrating an instrument to an accuracy immensely greater than that to which its scale can be read. Extreme accuracy in calibration seems to be particularly unnecessary in the case of the standard voltmeter; for, although the authors say that in calibrating it an error of 0·011 per cent. could readily be detected, yet (as was pointed out by Prof. Ayrton in the discussion on the Paper) in using the instrument with constants 0·05, and 0·1 (Table 2), errors amounting to 0·4 per cent. are neglected. These errors arise from the fact of the resistance of the galvanometer circuit not being very large when compared with that of the shunted coil of the potentiometer.

The second disadvantage Mr. Andersen mentions, viz., increased heating of the resistance coils, turns out to have no practical existence; for even with the larger currents required by the platinoid coil, the heating is so small as to make no appreciable error, even if the maximum current is kept passing for many hours. This will be proved by the calculations which follow; but before proceeding with them I may point out that the current in the platinoid coil, to give a deflection across the ampere scale, is not, as stated by Mr. Andersen, 21·5 times as great as that required by the copper coil, but in reality 17·2 times that value. However, the heating is so insignificant that one can well afford to assume that the platinoid coil requires 21·5 times as much current as the copper one; and to make the comparison as unfavourable as possible for the platinoid coil, I will make this assumption. It should also be observed that the number of ohms to be put in series with the platinoid coil will only be 1/21·5 of those required with the copper coil; hence, although the heat generated in a coil of a particular resistance will be 462 times as great, yet the total heating will be only 21·5 times as great.

It also follows that 1,000 ohms will be more than sufficient to put in series with the platinoid coil, and consequently the highest value for any single coil will be 400 ohms. This coil being of the highest resistance would be wound with finer wire than the rest of the coils; and since all the coils carry the same current, the heating in the 400-ohm coil will be greater than in any other. If, therefore, it can be shown that the heating of this coil is unimportant, still less important will that of the other coils be.

The power spent in a coil of resistance R is $C^2 R$ watts.

In the case under consideration $C = 1419 \times 10^{-6}$,

and $R = 400$

$$\therefore \text{ watts} = \left(\frac{1419}{10^6}\right)^2 \times 400$$

$$= 0{\cdot}000805.$$

This reduced to calories (water gramme C°) gives

0·000194 calories per second,

or, 0·7 calories per hour.

Now, the wire on a 400-ohm coil (taking Messrs. Elliott's ordinary G.S. boxes as basis) will weigh about 2oz. (56·7 grammes); and, since the specific heat of platinoid is about 0·09, this gives a water equivalent of 5·1 grammes.

To find the actual rise of temperature of such a coil when a current of 1,419 micro-amperes had been passing through it for a given time, one would require to know many conditions; but to simplify matters, and to make the case as bad as possible for platinoid, let us assume that all the heat generated in the coil is used in raising the temperature of the metal, and that not a trace of it escapes by radiation, convection, or conduction. On this assumption, the temperature of the 400-ohm coil would be raised 1°C. in 7¼ hours, and to change the resistance of the coil by one-tenth per cent. would necessitate the maximum current being kept on for 32 hours.

It will be evident to all that radiation, &c., would prevent even a change of this small amount ever occurring; hence the larger currents needed by the platinoid coil would never introduce any appreciable error in an apparatus designed to measure to an accuracy of $\frac{1}{5}$ per cent. Mr. Andersen's "Disadvantage No. 2" of platinoid is, therefore, of no practical importance.

His third objection is somewhat more reasonable; for, as he shows, the bulk of metal in the winding is certainly increased. But the total weight (and that is the important point) I shall show is but slightly increased. The bulk of the winding (metal and silk) remains unaltered, but in the copper coil the ratio of silk to copper is about 3 to 1, whilst the ratio of silk to platinoid is 1 to 2·5. The copper frame on which the coils of instruments of the pattern employed at Thames Ditton are wound usually weigh from 4 to 6 grammes (say 5 grammes), whilst the metal in the 420-ohm copper winding is about 0·8 gramme. The silk and varnish may be taken as 0·3 gramme, which gives a weight of 6·1 for the copper coil; that of the platinoid coil would be, frame 5·0, platinoid 2·7, silk, &c., 0·1—total 7·8 grammes. The ratio of the weights is therefore $7{\cdot}8/6{\cdot}1 = 1{\cdot}28$.

Now, the breaking load of a platinoid suspension wire such as is used in the instrument under discussion is about 180 grammes, hence with the heavier coil there is a factor of safety of 23, which is quite large enough for the purpose. Consequently, the small extra weight of the coil introduces no disadvantage on account of stress in the suspending wire, and the only disadvantage it has is to cause the period of oscillation to be slightly longer. For example, if the period is 1 second for the copper coil, it would be 1⅛ seconds for the platinoid one.

Having shown the true nature and importance of Mr. Andersen's "disadvantages," I desire to point out that *the chief advantage* of the platinoid coil is that no temperature correction whatever is required for the galvanometer and resistance coils. Such a galvanometer, combined with rheostat B at Thames Ditton, could be used to measure currents up to 550 amperes to an accuracy of $\frac{1}{5}$ per cent., without any temperature corrections being made. For larger currents the heating of the rheostat would have to be allowed for, but for this only.

A workshop instrument for measuring current, to be satisfactory, should require no temperature corrections of any kind; and this can be attained by using a platinoid-wound d'Arsonval instrument and a platinoid rheostat, designed so that the maximum rise of temperature caused by a prolonged passage of the largest current to be measured does not exceed 5°C.—Yours, &c.,

T. MATHER.

Central Institution, January 5, 1892.

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ACCUMULATORS FOR SUPPLY STATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As so much has been said about the inevitable losses which the use of accumulator storage entails on an electric supply system, we think this is a fitting opportunity to enclose the annual report we have just received from the engineer of the Kensington and Knightsbridge Company, which has been our oldest customer, and has continuously used our accumulators for nearly seven years. We give you the figures exactly as received, although they show a low efficiency during last January and February, due to the fact that owing to the exceptionally severe weather the temperature was so low that they were working in an exceptionally unfavourable manner. As soon as means were provided for maintaining the battery rooms at a regular temperature, the efficiency at once rose to the average of the year, viz., 79 per cent. These efficiencies are the actual commercial efficiencies taken at the recording meters; the losses include not only the losses in the batteries themselves, but those due to the resistance of the charging leads which connect the distant accumulator station with the generating station. The losses shown, therefore, are accurately representative of the total losses due to the use of accumulators for that part of the output which passes through them. This at Kensington is one-eighth part of the whole output, so that the use of accumulators in this station during the past year has only entailed the loss of 2½ per cent. of the entire output. Mr. Miller's remarks are interesting in showing that the efficiency obtained from the home batteries, which does not include losses in charging mains, is practically in excess of 85 per cent.—Yours, &c.,

CROMPTON-HOWELL ELECTRICAL STORAGE COMPANY (LIMITED).

Mansion House-buildings, London, E.C., Jan. 24, 1892.

Work done by Accumulators in 1891.

Kensington Court and Queen's Gate Batteries.					Kensington Court only.			
Month. 1891.	Charge in amp. hrs.	Discharge in ampere hours.	Efficiency amp. hours	Efficiency watts.	Charge in amp. hours.	Discharge in amp. hrs.	Per cent. amp. hours	Per cent. watts.
Jan. ...	113,174	77,593	68·6	66	...	...	...	...
Feb. ...	96,603	74,005	76·6	69	45,742	41,277	90	83
Mar. ...	82,977	73,230	88·3	78·5	...	...	...	...
April ..	101,021	90,487	89·1	79	46,868	43,142	92	85·5
May ...	89,257	82,274	92	80	43,311	40,525	93·5	86·6
June ...	95,603	88,028	92	80·5	...	...	...	...
July ...	99,778	91,864	92·2	86	39,015	26,549	93·5	86·5
Aug. ...	78,856	71,283	90·5	84	...	...	...	...
Sep. ...	75,274	68,416	91	84·5	33,873	31.265	92·5	85·5
Oct. ...	91,814	83,919	91·4	80·5	46,349	42,350	91·5	85
Nov. ..	104,114	96,987	93	86	...	...	...	...
Dec. ...	115,555	104,052	90·5	81·5	..	...	...	...
Totals..	1,144,036	1,002,137	88	79·5	...	...	...	...

During January no provision had been made at the Queen's Gate battery station for heating, so that the efficiency fell very low.

During March improvements were made in the system of charging the batteries, hence the increased efficiency.

The efficiency in watts cannot be calculated direct from the figures given for ampere-hours, as the results depend upon the proportion of work done by the batteries at each station; owing to the fall of potential in the charging mains to Queen's Gate, the watt efficiency at that station must be lower than at Kensington Court; also it depends on the amount of charging done separately or in connection with the lighting.

A few readings are given, showing the efficiency of the Kensington Court home battery, taken by themselves in order to show how considerably the loss in the charging mains reduces the total average efficiency for the year. (Signed)

H. MILLER, Kensington Court, Resident Engineer.

Proposed Utilisation of the Water of the Radaune.—A project is on foot for utilising power derived from the water of the Radaune. It is proposed to convey the water for some distance in underground tubes, and it is expected that 10,000 H.P. hours will daily be available for distribution in the neighbourhood of Dantzig. The cost of the work has been estimated at £1,000,000.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Offices not later than first post Thursday morning.*]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS INVITED.—The Municipality of Irun, in Spain, invite tenders for the erection of an electric light central station. Particulars may be obtained from the Alcalde, Señor Nicolas Guerendiain, to whom tenders are to be handed at noon on January 20th. Each person tendering must deposit a sum of 19,500 pesetas, which will be immediately returned to unsuccessful applicants.

——— The Bristol Urban Sanitary Authority invite tenders for piling the site of the central electric lighting station at Temple Back, Bristol.

COLONIAL AGENCIES.—We have received a letter from Messrs. Thomas T. Draper and Co., of Melbourne, notifying their ability to accept agencies for electrical plant and apparatus in Australia, and they offer any house wishing to do business with them satisfactory bank references in London.

ALMANACKS AND DIARIES.—We have received a paper-knife from the Eastern Telegraph Company, on the handle of which there is an calendar for 1892, the blade bearing a map of this Company's cable system and connections.

——— From Crompton and Co. (Limited) we have received a neat little de la Rue "Thumb" condensed diary, giving some particulars with regard to Crompton dynamos, motors, and arc lamps.

——— The staff of the Commercial Cable Company have sent us a handsome Christmas and New Year's Card, in the shape of a well-executed photogravure of the repairing ship "Mackay-Bennett."

PRITCHETT BROTHERS.—We are notified that Mr. G. E. B. Pritchett, of 1, Hanway-place, Oxford-street, W., has taken into partnership his brother, Mr. T. W. Pritchett, and that the firm have removed to 31, Soho-square, W., where business will be carried on in future under the title of Pritchett Brothers.

CHARLESWORTH, HALL, AND CO.—We are informed that Messrs. Appleton, Burbey, and Williamson, of 92, Queen Victoria-street, E.C., have been appointed London agents to Messrs. Charlesworth, Hall, and Co.

CATALOGUES AND INFORMATION WANTED.—A correspondent writes us as follows: "On behalf of a foreign Government I beg to ask, through your columns, for catalogues and for illustrated matter of systems and machinery for telegraphs (land and submarine), telephones, lighting by all systems, obtaining power from waterfalls, and any good chemical applications of electricity to tanning and similar processes, also relating to instruments of precision for military and naval purposes. English language preferred. Being only an agent, it is useless to call on me. Details will be gone into hereafter." Our correspondent is known to us, and if those of our readers who can assist him in getting this information together will address their communications to the Publisher of *The Electrician*, care shall be taken that the communications, printed or otherwise, do not go astray.

THE PAST YEAR'S WORK.—Messrs. Drake and Gorham, whose speciality is country house lighting, notify us that, notwithstanding the fact of Mr. Drake's serious accident at the New Scotland Yard, and his consequent disablement, they have carried out about 50 installations during the past year, many of which were of considerable magnitude. Amongst these installations may be mentioned the lighting of parts of the Westminster and St. George's Hospitals, and the design and supply of special electrical apparatus for use in connection with surgical operations, and the work for the London County Council at the Weights and Measures Testing Station, Newington. In the Instrument Department, the Cardew voltmeters, the patents for which are held by Messrs. Drake and Gorham, have had a large sale, and the Cardew earthing device has been during the year formally approved and sealed by the Board of Trade. D.P. Batteries have also been received with favour by the trade, &c.

——— The General Electric Power and Traction Company (Limited) has reached the end of its first financial year, and, in spite of the legislative and local obstacles to electric traction, considerable progress has been made. The service of electric cars at Barking has been improved, and, owing to the experience there

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gained in estimating for maintenance contracts on a large and commercial scale, the Company has reason to expect traction orders to the extent of £150,000 during the coming year. The sub-contract with the Electrical Power Storage Company for the maintenance of the accumulators at a fixed mileage rate removes the only doubt which capitalists may have had for the success of this form of electric traction. At Liverpool, a self-contained car was successfully run for some months with ordinary cars; and a motor car is being built for use in Birmingham. In mining work the Company has fully doubled the quantity of work done in this department in the preceding year; and in launch work, during the busy periods of last season the Company practically controlled the pleasure traffic of the Thames. An electric pinnace of the man-of-war type at the Naval Exhibition, shown equipped ready for slinging in davits, has led to three sea-going boats, 50ft. in length, being despatched to Russia. On Lake Windermere the Company's launches were usefully employed during the whole of the season, and arrangements have been concluded with the Manchester Ship Canal Syndicate by which a fleet of electric launches will run on part of the Ship Canal early in the spring. The Company are about to erect an extensive electric copper refining plant on the banks of the Thames, which they hope to have in full operation about April next.

COMPANIES' MEETINGS & REPORTS.

Mutual Telephone Company (Limited).

A meeting of the shareholders of this Company was held in Manchester on Thursday last, Mr. A. D. Provand, M.P., in the chair, when the following report of the Directors was read :—

The Directors have the pleasure of submitting to the shareholders their first report and statement of accounts, made up to Oct. 31, 1891. The accounts do not represent an ordinary working period, but must be submitted in order to conform to the requirements of the Articles of Association. The capital account shows that from the formation of the Company to Oct. 31, 1891, the sum of £21,539. 2s. 6d. has been expended on the construction of the Company's exchange system in Manchester, and that £1,574. 16s. 8d. has been expended in other places where it is proposed to open exchanges. The revenue account represents only a working period of four months, viz, from July 1 to October 31, 1891, the former being the date from which, with the exception of £191. 15s. previously charged, the Company commenced to earn revenue. This account shows a gross rental of £3,906. 5s., of which £1,145. 1s. is applicable to this period, and £2,761. 4s. has been carried forward to next account, as representing rentals received in advance for periods extending beyond October 31, 1891. The amount at the credit of the account is £378. 11s. 7d., which the Directors propose to carry forward.

The business of the Company is proceeding in a very satisfactory manner. At the date of this report, 840 instruments are in connection with the Company's exchange. This leaves a large number of applicants still to be joined up, while additional applications are being received daily. Attention is also being given to the work of connecting by trunk wires the various manufacturing centres around Manchester, and your Directors hope before long to offer to the subscribers these facilities. Arrangements have been made to open call-boxes on the main boards of the Royal Exchange, and these will shortly be ready for the use of subscribers to the Company's system.

The Directors feel that they may congratulate the shareholders upon the Company having already proved itself an accomplished success, both in respect of the advantage of the metallic circuit (*i.e.*, the double wire), as affording clearness of speech, and as confirming the views held by the promoters of the Company that a telephone service, worked with the most modern improvements, can be supplied at rates much below those hitherto charged.

The retiring Directors are Messrs. Provand and Southern, who, being eligible, offer themselves for re-election. The auditors, Messrs. Thomas Wade, Guthrie, and Co., also retire, and are eligible for re-election.

The report was adopted, great gratification being expressed at the favourable state of affairs disclosed therein; and the retiring directors and auditors having been re-elected, the proceedings, which were merely formal, closed with the usual vote of thanks to the chair.

Eastern Telegraph Company (Limited).

The following is the report and accounts of the Directors for the half-year ended September 30, 1891, to be presented at the thirty-ninth half-yearly ordinary general meeting, to be held at Winchester House, E.C., on Thursday, January 14, at 1 p m. :—

The revenue for the period amounted to £354,939. 5s. 4d., from which are deducted £97,130. 15s. 1d. for the ordinary expenses and £47,047. 18s. 1d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £4,816. 5s. for income-tax, there remains a balance of £205,944. 7s. 2d., to which is added £313. 15s. 9d. brought from the preceding half-year, making a total available balance of £206,258. 2s. 11d.

From this balance there have been paid—			
Interest on Debentures and Debenture Stock.....	£28,274	12	10
Dividend on Preference Shares	20,474	3	0
Two interim dividends of 2s. 6d. per share each on ordinary shares	100,000	0	0
	£148,748	15	10

Leaving a balance of £57,509. 7s. 1d., which is carried forward to the next account.

The revenue includes £33,398. 18s. 5d., dividends for the half-year upon the Company's shares in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies.

The traffic over our whole system is satisfactory, and the revenue derived from Australian telegrams since the reduction of tariff is developing favourably.

In accordance with the provisions of the Articles of Association, two of the Directors, Sir A. J. Leppoc Cappel, K.C.I.E., and Lord Sackville A. fCecil, retire by rotation at this meeting, and, being eligible, offer themselves or re-election. The Auditors, Mr. Henry Dever and Messrs. Welton, Jones, and Co., retire, and offer themselves for re-election.

Direct United States Cable Company (Limited).

The following is the report of the Directors of this Company for the six months ended December 31, 1891, to be presented at the twenty-ninth ordinary general meeting, to be held at Winchester House, E.C., on Friday, January 15, at 2 p.m. :—

The half-year's revenue (subject to revision on settlement of the case mentioned below) after deducting out-payments, amounted to £45,402. 0s. 8d. against £43,346. 13s. 7d. for the corresponding period of 1890, being a difference of £2,055. 7s. 1d. in favour of the half-year under review.

The working and other expenses for the same period, including income-tax, but exclusive of cost of repairs of cable, amounted to £17,672. 16s. 5d., leaving a balance of £27,729. 4s. 3d. as the net profit, making, with £3,502. 1s. brought forward from the previous half-year, a total of £31,231. 5s. 3d. For the corresponding period of 1890 the working expenses and other payments amounted to £17,555. 12s. 7d.

Interim dividends of 3s. 6d. per share for the quarter ended September 30, 1891 (paid October 24, 1891), and of 3s. 6d. per share for the quarter ended December 31, 1891 (payable January 23, 1892), together amounting to £21.248. 10s. have been declared; and, after setting aside £5,000 to the reserve fund account, the balance of £4,982. 15s. 3d. on the revenue account has been carried forward.

During the period under review an interruption to the main cable, occasioned by a vessel's anchor, occurred near Artimon Bank, and was promptly repaired. The cost of the repair (£4,478. 0s. 10d.) has been charged to the reserve fund account as heretofore.

Permanent station buildings are about to be constructed at Ballinskelligs, co. Kerry, at an estimated cost of about £4,000, to replace the temporary wooden structures erected 17 years ago.

In the case of the Anglo-American Telegraph Company *v.* Cie. Française du Télégraphe de Paris à New York, the hearing by the Court of Appeal on the question of damages is still pending.

NEW COMPANIES, STATUTORY RETURNS, &c.

ST. PAUL'S PRINTING AND PUBLISHING COMPANY (LIMITED).—This Company was registered on Dec. 31, 1891, with a capital of £10,000 in £1 shares, by R. Hewlett, 31, Essex-street, Strand, W.C. Objects: to establish, print, and publish a newspaper or newspapers, trade journals, magazines, and other publications in England; to acquire the whole or any part of the business, property, and liabilities of any person or Company carrying on any business which this Company is authorised to carry on, or possessed of property suitable for the purposes of this Company, including the copyright of any book, magazine, trade journal, newspaper, or other publication, and to carry on the business of newspaper proprietors, printers, publishers, booksellers, &c. The subscribers are :—

	Shares.
Henry Alabaster, 14, Therapia-road, Honor Oak, publisher	1
T. Ernest Gatehouse, 22, Paternoster-row, London, publisher	1
John Hunt, 222, Upper Thames-street, London, paper merchant.....	1
William G. Wicken, 41, Redcar-street, N., compositor	1
William B. Warwick, 1, Saunders terrace, Wellesley-road, Leytonstone, engraver	1
Edgar S. Middleton, 510, Holloway-road, London, N., book-keeper and clerk	1
Jarvis E. Osborn, 8, Wicklow-street, King's Cross, W.C., publisher's clerk	1

The qualification of every Director appointed by the subscribers of the Memorandum of Association, or subsequently, shall be the holding in his own right of shares or stock of the Company of the nominal value of £200. A Director may, however, act before acquiring his qualification. For the rest, the regulations of Table A, set forth in the schedule of the Companies' Acts, 1862, mainly apply.

CENTRAL ELECTRICAL COMPANY (LIMITED).—This Company was registered on December 28, 1891, with a capital of £50,000, divided into 5,000 Preference and 45,000 Ordinary shares, by T. T. Hull, 22, Chancery-lane, W.C. The objects are to adopt and carry into effect an agreement

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expressed to be made between Knud Sando and the Company to carry on the business of electricians, mechanical engineers, suppliers of electricity for the purposes of light, heat, motive-power, or otherwise, and manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. Unless otherwise determined by a general meeting, the number of Directors is not to be less than three nor more than seven, the first to be appointed by the subscribers to the Memorandum and Articles of Association. Qualification, £100 ; remuneration, £100 each per annum, and 10 per cent. of the net profits divided between them. Solicitors: Messrs. J. and H. Gregory, Leslie, and Hartley, 15, Union-court, Liverpool.

CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).—An agreement made December 29, 1891 (and filed on the following day), made between the above-named Company (referred to as "the Chelsea Company") of the one part, and the Brush Electrical Engineering Company (Limited) (referred to as "The Brush Company") of the other part, states that whereas, by an agreement, dated July 9, 1888, made between the Chelsea Company of the one part, and the Anglo-American Brush Electric Light Corporation (Limited) (referred to as "the contracting Company") of the other part, it was agreed that the contracting Company should supply, deliver, and fix in working order, in such place in Chelsea as the Chelsea Company might direct, certain plant, and that the Chelsea Company should issue to the contracting Company 84 fully paid up Founders' shares in the Chelsea Company, and should also pay £6,488 to the contracting Company ; and whereas the contracting Company have agreed, at the option of the Chelsea Company, to accept payment of all or any part of the contract price in fully paid-up ordinary shares in the Chelsea Company ; and whereas, by another agreement, dated July 31, 1888. made between the Chelsea Company of the one part and the contracting Company of the other part, it was agreed that the contracting Company should supply, deliver, and fix, in such places in Chelsea or Kensington as the Chelsea Company might direct, certain plant, and that the Chelsea Company should pay to the contracting Company the sum of £1,592 ; and whereas, by an agreement dated December 11, 1889, between the Chelsea Company of the one part, and the Brush Company of the other part, it was agreed that the Brush Company should accept payment of the whole of the amount payable under the agreement dated July 31, 1889, in fully-paid ordinary shares or in cash at the option of the Chelsea Company ; and whereas the Brush Company was incorporated for the purpose of acquiring the undertaking of the contracting Company (the said Company having resolved to wind up voluntarily) ; and by an agreement dated September 4, 1889, the contracting Company and its liquidators agreed to transfer and the Brush Company agreed to acquire as a going concern the real and personal property of the contracting Company ; and whereas certain additions to and deductions from the work specified in the agreements dated July 9, 1888, and July 31, 1889, have been agreed upon between the parties to this agreement ; and the Chelsea Company have exercised their option to pay the whole of the balances due under those contracts in ordinary shares of the Chelsea Company, to be issued as fully paid-up shares, and the sum of £3. 2s. 4d. in cash, and it is declared and agreed that the balances due under the last recited agreements are respectively £1,320 and £1,108. 2s. 4d., and 84 founders' shares of the Chelsea Company ; it is therefore hereby agreed that, in consideration of the work done and plant supplied, and in payment of the said sums of £1,320 and £1,108. 2s. 4d., the Chelsea Company shall issue to the Brush Company, 84 Founders' shares in the Chelsea Company, numbered 20,167 to 20,250 inclusive, 485 ordinary shares, numbered 4,532 to 4,856, from 6,854 to 6,891, and from 7,082 to 7,203 inclusive, the said shares to be considered as fully paid-up, and shall pay to the Brush Company the sum of £3. 2s. 4d. in cash. Registered office of the Chelsea Company: 12, Draycott-place, Chelsea, London, S.W.

"ECLIPSE" ELECTRIC LIGHTING SYNDICATE (LIMITED).—The annual return of the above-named Company, made up to December 31, 1891, was filed on January 1, 1892. The Company was registered on February 6, 1888, with a capital of £20,000, in £1 shares, the first Directors being Sir Charles Clifford, Bart., John Garford, Esq., and Valentine Robinson, Esq. By an agreement made February 4, 1888, between John Garford, Esq., of 3, Vernon-chambers, Southampton-row, London, of the one part, and W. H. Power (on behalf of the Company) of the other part, it was agreed that the vendor should sell and the Company should purchase the business of an electrician and mechanical engineer carried on at the White House, Telegraph-street, E.C., by the vendor, and also patents (1) No. 8,228, of July 7, 1885, United Kingdom ; (2) No. 4,744, of March 30, 1887, United Kingdom; (3) No. 21,745, of March 30, 1887 for Italy ; (4), No. 77,647, of May 31, 1887, for Belgium ; (5) No. 183,287, of May 3, 1887, for France ; and (6) 367,294, of July 29, 1887, for the United States of America. The purchase consideration was £15,000, of which £5,000 was to be paid in cash, and the remainder to be fully satisfied by the allotment of 10,000 fully paid up shares in the Company. At the date of making up 15,357 shares had been taken up, upon 4,380 of which the full amount had been called and paid. The remaining 10,777 had been issued as fully paid. The principal shareholders are Sir Charles Clifford, Bart., of 51, Cromwell Houses, South Kensington (1,072 shares) ; John Garford (4,497), B. Harrison, of the Grange, Leamington Spa (3,000) ; and Valentine Robinson, of 11, Poultry, Cheapside, London (1,951). Registered office : 2, Pancras-lane, Queen-street, London, E.C.

ELECTRICAL PURIFICATION ASSOCIATION (LIMITED).—The annual return of the Company, made up to December 30, 1891, was filed on the following day. The Company was registered on June 23, 1889, with a capital of £15,000, in £1 shares, to acquire and develop certain patents, No. 1,333, No. 15,760, No. 15,939, of 1887 ; No. 472, of January 11. 1888 ; and No. 4,105, of January 24, 1888, relating to the treatment of sewage and other impure liquids by electric action. In January, 1890, the capital was raised to £25,000, by the addition of 10,000 new shares of £1 each. At the time of making-up, 17,176 shares had been taken up, on 12,176 of which the full amount had been called, resulting in the payment of £11,659, leaving £517 in arrears. The remaining 5,000 had been issued as fully-paid. The principal shareholders are W. Webster, electrician, of The Grove, Lee, S.E. (2,600 shares) ; E. Webster, of 234, South Norwood-hill, S.E. (5,892) ; and T. Slater, of 19, Great George-street, Westminster, S.W. (2,542). Registered office: 22, Great George-street, Westminster London, S.W.

ISLE OF WIGHT ELECTRIC LIGHTING COMPANY (LIMITED).—The following notice was filed on December 31, 1891 :—At an extraordinary general meeting of the members of the above-named Company, duly convened and holden at the Mansion House-buildings, London, E.C., on Thursday, December 3, 1891, special resolutions to alter the Company's Articles of Association were unanimously passed. And at an extraordinary general meeting of the members, duly convened and holden at the above address, on Friday, December 18, 1891, the same resolutions were unanimously confirmed. One of the resolutions is, "That of the shares mentioned in the Memorandum of Association, 940 shall be called ordinary shares and 60 shall be called Founders' shares." The above-named Company was registered on November 12th last, with a capital of £1,000, in £1 shares. Registered office : 21, Lime street, London, E.C.

WILLIAMSON ELECTRICAL AND ENGINEERING COMPANY (LIMITED).—The following notice was filed on the 28th December, 1891. At an extraordinary general meeting of the above-named Company, duly convened and held at the registered offices, 14, St. Ann's-square, Manchester, on Tuesday, the 24th of November, 1891, special resolutions altering the regulations of the Company were duly passed, and at a subsequent extraordinary general meeting, also duly convened and held at the same place, on Wednesday, the 9th of December, 1891, the said special resolutions were duly confirmed. The annual return of the said Company, made up to the 23rd of December, 1891, was filed on the 31st following. The Company was registered on the 13th of September, 1889, with a capital of £5,000 in £10 shares, to carry on the business of electrical and general engineers in New South Wales. In July, 1891, the capital was raised to £25,000 by the creation of 2,000 new £10 shares. At the time of making-up 250 shares had been taken up, the full amount called and all calls paid. Mr. J. R. H. Williamson of 14, St. Ann's-square, Manchester, and 15, Pitt-street, Sydney, New South Wales, is the principal shareholder, having 43 shares. Registered office: 14, St. Ann's-square, Manchester.

KEIGHLEY ELECTRICAL ENGINEERING COMPANY (LIMITED).—An agreement made the 27th October, 1891, between H. Boardman, electrical engineer, of the first part, Ira Ickringill, of the second part, C. J. Garnett, electrical engineer, of the third part, A. Moore, of the fourth part, C. H. Seed, of the fifth part (called the vendors), and S. Hey (for and on behalf of the above-named Company), of the sixth part, states that whereas H. Boardman and Ira Ickringill are joint owners of Patent No. 7,720, dated 26th May, 1888, for "Improvements in Electric Tell Tales for checking watchmen and for other similar purposes," and Patent No. 3,878 of 1887, for an "Improvement in connection with Electric Alarm Checks," and whereas C. J. Garnett and A. Moore are the owners of the Patent No. 19,531, and dated December 1st, 1890, for "Improvements in means of automatically recording or checking the time of entrance of *employés* into factories, workshops, and the like," and the said C. J. Garnett is also the owner of the business of electrical engineer carried on by him at South Keighley, and whereas the said C. J. Garnett and A. Moore have verbally agreed to sell one-third share or interest in the patent owned by them, and whereas the above named Company was about to be formed with the objects of acquiring, working, and developing the said patents and business, it is therefore agreed that the Vendors shall sell and S. Hey shall purchase on behalf of the Company the patents, business, &c., described above, and in full consideration £3,300 shall be paid to the vendors. Full particulars of this Company were given in *The Electrician* of last week. Registered office (filed the 28th December, 1891): 8, Devonshire-street, Keighley, Yorkshire.

We are asked to state, with reference to a paragraph in our last issue, that the patents belonging to Mr. Joseph Slater Lewis have been taken over by The National Telegraph Works Company, Limited.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The Directors announce that they are prepared to receive applications for the unallotted balance of the Five per Cent. Perpetual Preference Shares. The traffic receipts for the week ended January 3rd amounted to £878, as against £805 for the corresponding period of 1890-91, an increase of £73.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of December were £3,400, as compared with £3,089 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of December, 1891, were £2,180, against £2,130, showing an increase of £50, as compared with the corresponding period of 1890.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of December, 1891, amounted to £55,830, against £55,058 in the corresponding period of 1890.

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EASTERN EXTENSION TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for December, 1891, amounted to £38,898, as against £43,482 in the corresponding period of last year.

ELECTRIC CONSTRUCTION CORPORATION.—In the January report of Mr. W. W. Duncan, discussing the value of various companies' stock, we find the following:—"In the two years this Company has been in existence it has returned to its shareholders 12 per cent. in the shape of dividends, has put £25,000 to its reserve fund, and has carried forward to next year nearly sufficient to pay a further 4 per cent. dividend. In addition it has written off capital for patent rights sold and amounts received for licenses the large sum of £120,000. It being able to produce such satisfactory results as a new company out of an enterprise which may still be said to be in its infancy, surely justifies the hope, with the strides that electricity is now taking, that we shall have much more brilliant results in the immediate future. This, to my mind, is a certainty, and I know of no better chance for exceptionally profitable investment than these shares afford, obtainable, as they are at present, at 7 for the £10 fully-paid shares cum 12s. dividend."

GREAT NORTHERN TELEGRAPH COMPANY (LIMITED).—The traffic returns of this Company in December, 1891, were £22,400; January 1st to December 31st, £282,600; corresponding months, 1890, £280,000; 1889, £274,800.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for December, 1891, were £2,364, showing a decrease of £252 as compared with the corresponding period.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Dec. 30.		Price Wednesday, Jan. 6.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Dec. 30.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/6	Anglo-American	50½	51½	50½	51½	5 1 11	Jan., Apr., July, Oct.	51	..
£2,849,510	Stock	25/0	Do. Preferred	88	89	88¼	89½	5 12 4	" "	89½	88½
£2,849,510	Stock	5/0	Do. Deferred	14	14½	13⅞	14¼	..	" "	14½	14
£250,000	100	4%	African Direct, Telegraph 4% Debentures xd	100	103	98	101	3 19 2	January and July	..	..
130,000	£10	3/0	Brazilian Submarine xd	10⅜	11¼	10½	11	7 2 3	Mar., June, Oct., Dec.	10⅜	..
£68,200	£100	5%	Do. 5 per Cent. Bonds	101	104	102	105	4 15 3	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906) xd	104	108	103	107	4 13 5	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock xd	149	151	151	153	4 11 6	April and October	153½	151
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	10¾	10½
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½	3⅝	3½	3⅝	6 18 8	April and October	..	..
6,000	5	10%	Do. Preference 10%	9⅝	10½	9⅝	10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10⅞	11⅛	10⅞	11⅛	6 6 2	Jan., Apr., July, Oct.	11⅛	11
400,000	10	2/6	Eastern	13⅞	14⅛	14	14½	4 11 3	" "	14 7/16	14
70,000	10	6%	Do. 6 per Cent. Preference	14¾	15¼	15	15½	3 17 5	" "	..	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	108½	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108	111	108	111	4 10 1	February & August	..	..
250,000	10	2/6	Eastern Extension	15	15½	15½	15⅝	4 11 1	Jan., Apr., July, Oct.	15½	15⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107	110	107	110	3 12 9	February & August	109¼	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 xd	104	107	102	105	4 15 3	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900 xd	103	106	101	104	4 16 2	" "	101	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	92	102	99	102	3 18 5	Febuary and August	..	..
180,227	10	2/0	Globe Telegraph and Trust	9⅞	10⅛	9⅞	10⅛	5 6 1	Jan., Apr., July, Oct.	10 1/16	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	14½	15	14½	15	4 0 0	" "	15	14½
150,000	10	5/0	Great Northern xd	19¼	19⅝	19	19½	4 7 2	Jan., April, and July	19½	19
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	107	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	43	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	7¾	8¼	7¾	8¼	4 16 11	April and October	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	117	122	117	122	4 18 4	" "	119½	118
15,609	10	3/0	West African Telegraph xd	7	8	7	8	6 5 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	97	100	97	100	5 0 0	March & September	..	..
30,000	10	2/0	West Coast of America	3½	4½	3½	4½	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902 xd	100	105	97	101	7 18 5	June and December	..	..
88,321	10	1/0	West India and Panama	1⅝	1⅞	1⅝	1¾	..	" "	1¾	1⅝
34,563	10	6%	Do. 6 per Cent. 1st Preference	9	9½	9	9½	6 6 4	May and November	9½	9⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7½	8½	7½	8½	7 1 2	" "	..	..
67,007	15	6/0	Western and Brazilian	10¼	10⅜	10¼	10⅜	6 19 5	" "	..	..
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6¼	6⅜	6¼	6⅜	5 7 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4	4½	4	4½	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	100	103	103	106	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	100	103	103	106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜	½	⅜	½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1 1/16	1 1/16	1 1/16	1 1/16	6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅜	4⅝	4½	4⅝	6 13 4	June and December	4⅝	4 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12¼	12⅝	12¼	12⅝	4 14 1	" "	12⅝	..
15,000	10	6%	Do 6% Cumulative 2nd Prf.	12	12½	12	12½	4 16 0	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd) xd	105	108	105	108	4 3 4	January and July	106½	105
58,000	5	1/0	United River Plate	1	2	1	2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock xd	80	90	80	90	5 11 1	.. "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£6 paid)	5½	6	5½	6	..	..	5¾	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
8,332	£5	..	House to House Electric	..	..	4½	5	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	..	..	5¾	6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	5½	6	..	January and July	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2¾	2⅞	2⅞	2⅞	..	March	..	..
10,000	£5	3½%	Do. (fully paid)	4⅞	5⅛	4⅞	5⅛	..	March	..	..
111,000	5	..	London Electric Supply	1⅛	1⅜	1	1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½	10	9⅛	10	..	..	10	9 1/16
6,318	10	..	Notting Hill Electric Lighting (fully paid)	6⅞	7⅛	6	7	..	..	..	..
18,680	£5	3/6	St. James' and Pall Mall	8½	9	8½	9	..	..	8⅞	8½
7,900	£5	7%	Do. 7% Preference	7¼	7⅜	7½	7⅜	..	..	7 1/16	7¼
42,853	5	..	Westminster Electric Supply (£5 paid)	6¼	6⅜	6⅛	6⅜	..	..	6⅜	6¼
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/8	Brush Electrical Engineering	3⅛	3⅜	3⅛	3⅜	..	..	3⅛	..
69,996	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	..	2⅛	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares xd	5¼	5⅜	5¼	5⅜	6 1 9	January and July	5⅜	..
17,130	5	17%	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	12/0	Electric Construction xd	6	6½	5⅞	6¼	..	—	6½	5⅞
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅛	3⅜	3⅜	4⅛	..	—	4⅛	3⅜
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20½	21½	20½	21½	4 15 3	February & August	21 1/16	20¾
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	4	5	4	5	..	..	..	..
11,334	£10	8/0	Do. Preference	8⅞	9½	8⅞	9½	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅜	⅝	⅜	⅝	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	4¼	4⅜	4	4½	8 11 10	May and November	4 7/16	4⅛
36,250	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July	43½	42¾
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894 xd	102	105	100	103	4 17 1	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	..	..	1⅞	2	5 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	..	..	3⅜	3⅞	10 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	—	—
50,000	£10	—	City and South London Railway	2⅛	3⅛	2⅛	3⅛	—	—	2⅜	—

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THE ELECTRICIAN:

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NOTES.

The proposals with regard to electric and magnetic units brought forward by M. Hospitalier at Frankfort will be found in the present issue. These proposals are neither revolutionary nor visionary; their author is neither anxious to discard the C.-G.-S. system and to begin again *de novo*, nor to do away with that obnoxious 4π and the many other obstacles which at present mar the simplicity of electro-magnetic calculations. Chemists and mathematicians have an international system of symbols and notation, and there is every reason, M. Hospitalier thinks, why electricians should have one also. The idea is not indeed new, though it has not before been so methodically worked out. Those who have the requisite leisure and knowledge of the subject will do well to refrain from the fascinating pursuit of word-coining and to turn their attention to these more practical and useful suggestions, with a view to their further improvement and their authorisation at the next International Electrical Congress. For our own part we fail to see any good reason for using the scrabbly *ronde* letters 𝔓, 𝔈, and 𝔅 respectively, for magnetising force, intensity of magnetisation, and magnetic induction, instead of the bold block letters **H**, **I**, and **B**, which have come into general use both in England and America, and have the added advantages of being easier to write and clearer to print.

A fortnight ago we alluded to the disinclination which is felt by a tenant with a short lease to present his landlord with fixtures in the shape of electric light wires, switches, and fittings. An attempt to meet this difficulty has been made in the formation of a Company for hiring and maintaining electric fittings; but a perusal of the prospectus does not convince us that it touches the real difficulty. The objects of the Company appear to be merely to wire houses and furnish fittings on the hire-purchase system. Not a word is said about the landlord, and "it is proposed that the amount should be spread over five years, in twenty quarterly payments." Few tenants with a three or four years' lease and an uncertainty of renewal care to go to the expense of wiring a house, nor would they even if the payments were spread as conveniently as possible and without interest. Five years, instead of being a maximum, should be considered as a minimum. Consumers will rarely look on the use of wires and switches as part of the expense of electric light, but consider it to be part of the value of the house, like the gas and water pipes.

An eight-candle lamp costs 8s. to 10s. a year for current, and costs from £1. 10s. to £2 to set up. The cost of wiring and fitting a house may therefore be said to approximately equal the cost of four or five years' consumption, or, in other words, to double the cost of electric lighting for the first five years. Assuming that electric lighting, if carefully managed, costs fifty per cent. more than gas, the annual total cost during the five years over which payment for fittings is spread will come to about three times the price of gas. The proposed Company does not thus offer much assistance to a five-year tenant. If he could pay a moderate sum for the use of the wires, just as he pays for the hire of a gas meter, and might leave the whole when he gave up the house, an immense increase of business would accrue to the supply companies. The hire-purchase system, besides encouraging too often disreputable practices on both sides, offers a sad temptation to persons with limited incomes to make a great show. The vendor is generally well protected and is often extortionate. But it does not appear that this new Company can have any rights to the wires, which must become landlord's fixtures. They say, "the business will be a safe one to the Company, as the fittings will remain its property until the expiration of the hiring period, and until all the instalments are duly paid." We assume that by "fittings" is meant brackets, lampholders, &c., which are not essential and are easily replaced.

So hard is it at present to answer the question, "What is electricity?" that many people would say that to attempt it is to waste time. A few weeks ago we discussed the much more elementary problem, "Does electricity exist?" But a discussion has arisen on the harder question; and the last contribution does not throw much more light on the matter. Our correspondent overlooks the fact that in the vast majority of cases the waste of energy in heating the wire is but a small part of the total energy conveyed by the current; so that whether energy is supposed to be carried with the current, or to flow through the dielectric, as the orthodox theory asserts, we must in either case assume that the larger part of the energy is conveyed without having any influence on the molecular structure of the wire. At the beginning of our abstract of Mr. Trouton's lecture on p. 280, our present knowledge of an electric current is clearly stated. The surrounding medium is thrown into a peculiar condition. It is hardly possible that this can be other than a displacement or strain. "Very few," says Dr. Johnson, "have abilities

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requisite for the discovery of abstruse truth; and o those few some want leisure and some resolution."

THE coloured map which forms the Supplement of the present issue shows the streets in which electric mains were laid down to the beginning of the present month. The same system has been adopted as in the map published last year, for indicating the competition of the different companies; but by means of ruled tints we have been able to show in addition the extent and the overlapping of the different districts. This map is on the scale of 2½ inches to the mile, being smaller than that of last year, in order to take in the mains of the St. Pancras system. We have not included the City, since no general supply was ready at the beginning of the year, although the work of laying the mains is at last being pushed on with alacrity. The distributing mains of the London Electric Supply Corporation on the south of theThames are not given, as they extend to a considerable distance eastwards. The New Cadogan Company only received its order a few months ago, and until then employed overhead wires; it has concurrent powers with the Chelsea Company; it will no doubt have made sufficient progress by next January to be worth recording.

OUR able contemporary, the *Journal of Gas Lighting*, has been led to imagine that the map which is published with the present issue was to be accompanied by some statistical information relating to the working capabilities of the various supply companies. We made no such promise, and hope that the tables which, according to our usual custom, appeared in our New Year's number will suffice for the present. These tables were but slightly modified from those of last year, for the result of asking a number of miscellaneous questions would merely be a few desultory replies and a great many of blanks. It seems uncertain whether the Board of Trade returns of the supply companies are to be published or no. We may be quite sure that some companies will have no hesitation in throwing them open to public inspection, while certain others will probably take advantage of privacy if no official publication is made. The chief point of interest, in our opinion, will not be the details which go to make up the 2d. of "sheer cost" of output, but those which absorb the 4d. to 6d. which is spent on distribution and general expenses. Our valued contemporary, as well as our other readers, shall have all the authentic information that we can obtain on this subject.

Montreal.—The Canadian Pacific Railway Company intend to start a telephone company in Montreal, in opposition to the Bell Company.

Prof. Hertz.—The Royal Academy of Science at Turin has awarded the Brescia premium of £500 to Prof. Hertz for his researches on electricity.

The Birmingham Compressed Air Power Scheme.—An order has been made for the winding-up of the Birmingham Compressed Air Power Company.

Telegraphic Extension in China.—The Chinese Government proposes to establish a telegraph line from Pekin to Kiakhta, in Siberia, where the Muscovite system at present terminates.

Madrid.—The Electric Supply Company of Madrid, an English company, says *Industries*, has lowered the price of electricity to 1s. per kilowatt hour. The present price of gas is 9s. per 1,000 cubic feet.

The Telephone Service in Belgium.—The Belgian Government has informed the Belgian Telephone Companies of its intention to resume from January 1, 1893, the working of all the telephone lines in Belgium.

Eastern Extension Telegraph Company.—The Eastern Extension Telegraph Company notify that their Hong Kong-Bolinao cable is now repaired, and telegrams can, therefore, be accepted for transmission to Manila as usual.

The Chicago Exhibition.—The plans for the electric lighting of the Chicago Exhibition have been completed, and tenders are about to be invited for the installation and working of plant and mains for 7,000 arcs and 120,000 incandescents.

Church Lighting.—The fine old cathedral of St. Nicholas, Galway, was for the first time publicly lighted by electricity on Christmas morning. The lighting is mainly by high-candle-power incandescent lamps, and is very satisfactory.

The Edinburgh Electric Supply Corporation.—We have received from this Company a pamphlet setting out the objects of the Company, the cost of lighting, &c., and giving information and particulars relating to electric light and power.

Professor Ayrton's Presidential Address.—At the meeting of the Institution of Electrical Engineers last evening, it was decided, owing to the death of the Duke of Clarence, to adjourn until the 28th inst., when Prof. Ayrton will deliver his Presidential Address.

Municipal Lighting.—The Wolverhampton and Walsall Town Councils have each decided to devote £21,000 to electric lighting.—The Watch Committee of the Chester Town Council have also decided to spend the sum of £20,000 on the electric lighting of the city.

Proposed Multiphase Central Station.—A central station is shortly to be built in Baden (Switzerland) by the firm of Brown, Boveri, and Co. The multiphase system is to be applied, and the dynamos, which are to be driven by turbines, are only to run at 40 revolutions per minute.

Telegraph Line to Gilgit.—The party sent to survey the telegraph line to Gilgit has, says the *Indian Engineer*, been obliged to return to Srinagar from Astor, owing to the road being impassable from heavy falls of snow. They will most likely remain there till February.

A Telegraph Pioneer.—A memorial tablet has recently been affixed to the house, now called Kelmscott House, Upper-mall, Hammersmith, occupied in 1816 by Mr. Francis Ronalds, afterwards Sir Francis Ronalds, F.R.S., who there constructed his first experimental telegraph line.

Dockyard Lighting.—The electric light has been introduced at Devonport Dockyard for lighting up the ships under construction there. This is the first time that anything of the kind has been attempted at Devonport, although the light has been tried at Chatham and Portsmouth.

Battersea Polytechnic.—A course of ten lectures on "Recent Applications of Electricity" is being delivered under the auspices of the University Extension Society, by Dr. J. W. Waghorn, in the Public Library, Lavender Hill. The first lecture was delivered yesterday evening.

Frankfort-on-Main.—The *Frankfürter Zeitung* announces that the project for building a central station at Frankfort is about to be carried out. Herr Oscar von Miller and Baurath Lindley have been entrusted with the preparation of the plans, and £500 have been voted for the preliminary expenses.

Electrical Utilisation of Water Power.—The Inverness Police Commissioners are inquiring whether the water-power in the neighbourhood of Inverness is capable of being utilised for electrical purposes. It is proposed to adopt a plan by which water could be got from the canal near Muirtown at a cost of £7,200.

St. Petersburg Exhibition.—We learn that the work of completing this Exhibition is progressing satisfactorily. A portable telegraph will be exhibited by Prince Lvoff; metal working by electricity will be shown by M. Slovinoff; and the Thomson-Houston Company are installing a number of motors for drilling and sawing purposes.

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Académie des Sciences.—At the meeting of the Académie des Sciences on the 21st ult. the La Caze prize was awarded to M. Violle for his work in connection with solar radiation, the determination of elevated temperatures and standards of light. For 1892 the subject of the Gay prize will be "A Study of Terrestrial Magnetism, and especially of the Distribution of the Magnetic Elements in France."

Thunderstorms.—On Friday last there was a considerable fall of snow on the north-east coast, and early in the evening at Newcastle and at Seaton-Delaval there was thunder and remarkably vivid lightning. About four o'clock on Saturday morning a thunderstorm took place at Hartlepool, which was renewed later in the morning, the lightning doing damage at the works of Messrs. Gray and Co., and injuring a workman.

Southend Pier Tramway.—In our issue of January 1st, under the heading of "Electric Tramways and Railways in the United Kingdom," we gave the length of Southend Pier as $\frac{1}{4}$ mile. It should read $1\frac{1}{4}$ miles. We may also state that, although the tramway was worked by the Local Board, up to the end of last season Messrs. Crompton and Co. contracted to find the labour and superintend the working for a certain sum.

Exhibition of Meteorological Instruments.—The Council of the Royal Meteorological Society have arranged to hold, at 25, Great George-street, from March 15th to 18th, an Exhibition of Instruments, Charts, Maps, and Photographs relating to Climatology. The committee will also be glad to show any new meteorological instruments or apparatus invented or first constructed since last March, as well as photographs and drawings possessing meteorological interest.

The Price of the Kilowatt Hour in Paris.—

Company.	1889.	1890.
Edison	Fr. 1·104	Fr. 1·237
Victor Popp	1·497	1·265
Place Clichy	1·499	1·368
Marcel-Deprez	1·367	1·119
Municipality	,,	1·100

For street arcs the companies' charges amount to 71 centimes per kilowatt hour.

"Electrical Plant," Central Lighting Station Number.—This profusely-illustrated publication describes the leading central stations of this country, together with a few Continental ones, and several private plants. It should be of service to those Town Councillors and vestrymen who journey about the country at the ratepayers' expense to visit engine-rooms and interview managers. A glance at its pages shows that it forms a useful record of modern central station practice.

Steam Electric Lighting Plant in Germany.—It is stated by the *Elektrotechnische Rundschau* that at the beginning of last year there were in Germany 731 stationary engines, giving 38,344 H.P., and 63 portables, giving 1,266 H.P., employed in driving electric lighting machinery. The total output would correspond to about 800,000 8-c.p. lamps. Besides these, 177 stationary engines and 12 portables (total 10,000 H.P.) were running electric machinery for other purposes. 16·07 per cent. of the whole power was being utilised in Berlin.

Telegraph Offices in the United States.—From a recent report of the Postmaster-General of the United States, it appears that in the New England States the average distance from the post office to the nearest telegraph office is four miles. In the Middle States the average distance to the nearest telegraph office is three miles. In the Southern States the average distance to the nearest telegraph office is nine miles. In the Western States the average distance to the nearest telegraph office is seven miles. In the Pacific States the average distance to the nearest telegraph office is 13 miles.

Storage Battery Litigation in the States.—On December 2nd an injunction was issued against the Electrical Accumulator Company, Theodore N. Vail and O. E. Madden, forbidding them to infringe the patents of Chas. F. Brush, March 2, 1886, No. 337,299, and October 17, 1882, No. 266,090, for secondary batteries.—On December 7th, a perpetual injunction was issued in the United States Circuit Court, Trenton, N.J., restraining the Accumulator Company from making storage batteries in infringement of the patents of Chas. F. Brush now owned by the Consolidated Electric Storage Company, the successors of the Julien Electric Company.

Endurance of Incandescent Lamp.—To show the capacity of incandescent lamps to withstand the weather, Mr. W. Claude Johnson writes to us as follows:—"I have maintained one of these lamps for four years in a most exposed position in my garden without any difficulty. The lamp is rigidly fixed at the top of a tubular shaft. . . . A concentric cable passes through a gland at the top of the shaft, where the lamp is fixed in a vertical position. The cable is connected directly to the platinum loops of the lamp, the joint being then neatly wrapped with pure para rubber strip, and over this a layer or two of compounded tape, which encloses a small portion of the glass bulb."

Reading.—The Lighting Committee presented a report at a recent meeting of the Town Council, in which they detailed the terms on which the Messrs. Laing, Wharton and Down Construction Syndicate undertook to light the central business area of the Borough by electricity, under the alternative of a five or a seven years' contract. It is estimated that the expense would be about half as much again as the present cost, and that the light would be about 15 times as great as that now enjoyed. The foregoing cost, however, would allow for the lamps being alight the whole night, whereas the gas lamps are entirely shut off or reduced a considerable part of the night.

Royal Engineers and the Institution of Civil Engineers.—The Institution of Civil Engineers has hitherto only accepted Royal Engineers as Associates. On retirement from the army, and on taking up civil engineering, a Royal Engineer, however, becomes eligible for full membership, but up till a short time ago, says *Engineering*, there had been no instance of any one taking advantage of this rule. But this precedent has at length been created, and Major-General Webber figures as the first ex-officer of the Royal Engineers to be accepted as a full member of the Institution of Civil Engineers. General Webber's application for membership was backed by the following names, amongst others, Sir C. H. Gregory, Sir F. Bramwell, Sir Douglas Fox, Mr. Preece, and Sir B. Baker.

The Electric Supply Mains at Liverpool.—On Monday last, at about one o'clock, a short circuit occurred in one of the service boxes of the Liverpool Electric Supply Company, in Parker-street. The initial cause of the short circuit was, as far as can be ascertained, some water which had leaked into the box connecting the conductors. The heat generated melted the bitumen lining of the box, and brought the conductors into contact with the iron. The lead fuses of the service lines entering the box were melted, and it is assumed that the spark at the point of rupture of these fuses set fire to the bitumen. Flames were observed issuing from the service plate over the box, which were promptly extinguished by a policeman on duty near the spot, who threw a quantity of sand over the service plate.

The Electrical Standardising, Testing and Training Institution.—During the earlier part of 1891 some time had to be spent in fitting up the new premises at Faraday House, Charing Cross-road. The standardising and testing departments have had continuous work since they were opened. A good deal of work has also been done by experimenters who rent the private rooms and borrow the apparatus as they require it. Much has been done in the direction of inspecting and reporting upon private installations, testing meters, &c., in cases where disputes have arisen between householders and their contractors or supply companies. In the training department some 50 names are on the books, and we are informed that the companies and firms in affiliation with the Institution have already drawn upon it for assistant engineers.

Suburban Electric Service.—According to the *Electrical World* of New York, the Illinois Central Railway authorities are contemplating the substitution of electric motors for locomotives on their suburban lines. The Illinois Central Railroad has a location at Chicago, says our contemporary, that is especially favourable to a first-class train service, inasmuch as its tracks lie along the lake shore for half-a-dozen miles without a single street crossing, and are walled in so that it is

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possible to run at almost any desired speed permitted by the necessity of frequent stops. This somewhat advantageous situation would operate in favour of electric traction both as regards speed and as rendering possible a power station within very easy reach of both coal and water supply. Nevertheless, the heavy traffic and frequent stops necessarily limit the speed and make the economy of such a substitution of motive power somewhat doubtful.

The Chelsea Electricity Supply Company.—At a recent meeting of the Kensington Vestry the Works and Sanitary Committee stated that pursuant to the reference by the Vestry of November 25th the Committee had considered the letters from the Board of Trade forwarding the description of the system proposed to be substituted by the Chelsea Electricity Supply Company, in place of that now in force; and recommended that the Board of Trade be informed that the Vestry saw no objection to the proposed new system being adopted, provided a code of rules and regulations similar to those now in force be imposed by the Board. We are informed that this so-called change of system is merely the addition of some continuous-current transformers at the sub-stations, and some direct-running machines at the Central Station for supplying immediately around that station; on account of this the Board of Trade thought it necessary to draw up a revised description of the system.

Royal Society Grants.—The following are a few of the sums appropriated by the Royal Society from the annual Government grant (£4,000) for the advancement of science. E. H. Griffiths, for apparatus required in a re-determination of the value of Joule's equivalent, £50. H. L. Callendar, for the manufacture of a standard platinum thermometer, and the comparison of the same with an air thermometer at high as well as low temperatures, £80. Prof. J. V. Jones, for a further determination of the ohm by the method of Lorenz, £50. Prof. Rücker, and Prof. Thorpe, towards the expense of a magnetic survey of the United Kingdom, £600. Dr. H. Marshall, for a research on the oxidation of various substances (salts, acids, &c.) by means of electrolysis, £25. W. A. Shenstone, for payment of an assistant in investigating (1) the influence of the silent discharge of electricity on gases, (2) the conditions of the formation of haloid salts, £50. Prof. D. E. Jones, in aid of an investigation on Hertzian vibrations, £35.

Government Control of Telegraphs.—In the discussion on Mr. Rosewater's Paper (see *The Electrician*, December 18th, p. 159) on this subject, which took place recently at the New York Electric Club, Mr. Allen R. Foote made some interesting comparisons between the English and American service. Between 1887 and 1889 the number of telegraph offices in the United States was increased by 20 per cent., against an increase of 8 per cent. in England. In the United States there is one telegraph office to every 2,400 of the population; in England there is one to every 5,500. In England we have one office to every 17·27 square miles; in America they have one to every 171 square miles, the populations per square mile being in the ratio of 100 to 5·6. In the United States a message averages close on 22 words, for which the charge in this country would be 11d., but which costs 1s. 8½d. across the Atlantic. The average mileage of a message in America is, however, 540 miles. The longest possible distance in England is 600 miles. Mr. Allen R. Foote opines that one reason why so many people go to America must be "to enjoy the privilege of telegraphing at the low price charged by our grinding monopoly." It is a pity no comparative statistics were given as to the average time an average message takes to go an average distance in the two countries respectively.

The Receipts and Expenditure of the Paris Exhibition.—The *Economiste Français* publishes a detailed analysis of the receipts and expenditure connected with the Exhibition of 1889, the net financial outcome of the Exhibition being a balance of about £400,000 to the good. The receipts were made up of the money paid for admission, the produce of different concessions and lettings of space, the sale of materials afterwards, the subsidy of the city of Paris, and the amount contributed by the State. The receipts of the 1867 Exhibition were £1,050,000, while those for the Exhibition of 1878 did not amount to more than £927,000, including a subsidy of £248,000 from the city of Paris. Upon the other hand, the expenses of the 1889 Exhibition, which had been estimated at £1,860,000, did not amount to more than £1,600,000, while for the 1867 Exhibition they were £936,800, and for that of 1878, £2,216,000, including a sum of £560,000 spent upon the Palace of the Trocadéro. In other words, while the 1889 Exhibition left a profit of £400,000, that of 1867 gave one of only £112,000; and that of 1878, organised at the cost of the State, left a deficit of £1,268,000. It should be pointed out, however, that in 1878 there was no subsidy from the State, whereas in 1889 the State contributed £680,000, and in 1867 £240,000.

Electric Lighting and Heating in the Highlands.—In its issue of January 9th the *Field* gives some particulars with regard to an interesting little application of water-power to electric lighting and heating purposes at a shooting-lodge in the West Highlands. A dam was built across a small mountain burn some 800ft. above the lodge. The water is led for some distance past the dam in an open drain, and at a point about 650ft. above the turbine; it is conducted to it in a closed pipe. The waterfall thus made is the highest that is used for electric lighting purposes in the British Isles. The current is conveyed from the turbine house to the various buildings, the lodge about 200 yards distant, the stables, laundry, and head stalker's cottage some 400 yards distant, by means of insulated conductors laid underground in tarred wood troughing, and the cables are completely protected by melted bitumen run into the troughs. In all, there are some 292 electric lamps installed. An interesting feature of the installation is a system of electric stoves, which are used for warming and keeping dry the cellars and various other parts of the buildings. The whole of the electrical installation was designed and carried out by Mr. J. C. Howell, of Queen Victoria-street, the turbine and water arrangements being carried out by Messrs. Carrick and Ritchie, of Edinburgh.

Artificial Production of Rain.—At the close of a Paper read before the Electrical Section of the Franklin Institute, Prof. Edwin Houston said that the following general conclusions may, in view of the present state of meteorological science, be properly drawn concerning the artificial production of rain:—1. That rain can never be made to fall at will by mid-air explosions on any part of the earth's surface irrespective of the climatic conditions there existing. 2. That during certain meteorological conditions mid-air explosions may result in rainfall over extended areas. 3. That the liberation of energy necessary for such rainfalls is due not to the mid-air explosions, but to the energy stored up in the moist air from which the rain is derived. 4. That the meteorological conditions which must exist for the successful action of mid-air explosions would probably, in most though not in all cases, themselves result in a natural production of rain. 5. That a comparatively high difference of electric potential between different parts of the air, or between the air and the earth, is possibly favourable when taken in connection with other meteorological conditions for artificial rain-making. 6. That an undirected mid-air explosion is not as likely to produce rain as an explosion in which the main tendency of the energy liberated is to cause a general up-rush of the air.

An Incident in a New York Telegraph Office.—Last month at a very busy moment in the New York office of the Western Union, the Baltimore quadruple suddenly broke down. A New York daily describes the incident as follows:—"Wire Chief Durivan was called to adjust the instruments. He pottered over them for some time, and concluded that there was a bug on the wire somewhere between New York and Baltimore. The telegrapher's definition of "bug" is "trouble." The instruments were taken off the wire and the wire was tested. It was found to work splendidly. When the instruments were replaced, however, the wire would not work at all. There were no other instruments available, and the connection with Baltimore was completely lost. Electricians were sent for, and they began a thorough examination of the instruments. After half an hour's search they found the bug, not on the wire,

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but on the instruments. It proved to be a Croton bug. It stood on the instrument which regulated the passage of the electric current from the dynamo to the wire in such a way as to connect with its fore and hind legs the positive and the negative currents. The bug was dead, of course, and the current of 250 volts had fairly glued it to the metal, thereby forming a conductor interrupting business between New York and Baltimore for more than half an hour."

Electric Heaters.—In the States a large number of electrical heaters have been proposed. As showing their economic inefficiency, they are compared with the cost of gas used in gas stoves for domestic and other purposes. In the paper by Mr. George H. Christian, published in *Engineering News* of May 30 the fuel gas, at 50 cents per 1,000ft. was stated to furnish a given amount of heat at the same cost as hard coal at 7·50 dols. per ton. But with the exception of the natural gas regions there are few cities where gas for heating purposes can be had at this rate. A common price, however, is 1 dol. per 1,000ft., and at this price it is generally considered a very expensive fuel, even for cooking purposes. The total calorific value per 1,000ft. of gas may be taken as 400,000 heat units. The prices of electricity in New York City vary from 14 cents per horse-power hour for incandescent lighting to from 5 cents to 10 cents or more per hour for power purposes. One horse-power, 33,000 foot-pounds per minute, 1,980,000 foot-pounds per hour, equals 2,565 heat units. If 2,565 heat units obtained from electric energy cost 5 cents, for a dollar we can obtain 20 times as much, or 51,300 heat units, assuming no losses. But a dollar's worth of gas will furnish 400,000 heat units; hence the electric heating is nearly eight times as expensive as the heating by gas at 1 dol. per thousand feet.

Portsmouth.—At its meeting last week, the Town Council discussed Prof. William Garnett's proposals with regard to the electric lighting of the town. Prof. Garnett's scheme involves the use of alternating currents at 2,000 volts pressure, turbo-electric generators, and concentric mains. For public lighting Prof. Garnett recommends 150 c.p. incandescents placed 90 feet apart. The capital expenditure for an 18,000-light central station, supplying also 200 public lamps, is estimated at about £38,000, exclusive of cost of site. The annual revenue is figured out at £10,800, and the total expenditure at £7,572. From the discussion on the Electric Lighting Committee's report, it seems that the revenue is based upon every 8-c.p. lamp wired earning 10s. per annum. In presenting the scheme summarised above, the Electric Lighting Committee reported that they had had reason to reconsider the scheme prepared by Mr. Shoolbred, and they had obtained a further report upon the subject from Prof. Garnett, which they now submitted for the consideration of the Council. The Committee recommended that the resolution of the Council passed on September 8th last, so far as it referred to the adoption of Mr. Shoolbred's scheme, be rescinded. They further recommended that the scheme and report of Prof. Garnett be adopted, and that he be appointed as consulting engineer, and that Messrs. Waller and Maneville be appointed as superintendent engineers. An amendment was moved, deferring the consideration of the report for a fortnight, and was carried by 16 to 12.

Western Union Telegraph Company.—The following statistics appeared in a recent issue of *Engineering*. (We have taken the liberty of converting our contemporary's dollars into pounds sterling.) The revenue of this great undertaking for the financial year ending June 30, 1891, was £4,606,865, as compared with £4,477,405 in 1889-90. In 1879-80 the revenue did not exceed £2,556,578, and in 1869-70 it only amounted to £1,427,747. The profits realised in 1890-1 were £1,321,117, as compared with £1,462,545 in 1889-90. In 1879-80 the profits did not exceed £1,166,787, and in 1869-70 they only amounted to £445,421. The enormous expansion of the Company's business is shown in the fact that the number of telegrams despatched by it last year was 59,148,343, as compared with 55,878,762 in 1889-90, 29,215,500 in 1879-80, and 9,157,646 in 1869-70. In 1890-1 the Company had 20,098 offices in operation; the corresponding number in 1889-90 was 19,382; in 1879-80, 9,077; and in 1869-70, 3,972. In 1890-1 the Company had stretched 715,591 miles of wire. In 1889-90 the corresponding length of wire was 678,997 miles; in 1879-80, 233,534 miles; and in 1869-70, 112,191 miles. The Company has been compelled by the force of circumstances to pursue a policy of progressive enterprise, and also to absorb all competitive undertakings as much as possible; hence the prodigious growth of its system and business. The Company was chartered in April, 1856, with a capital stock of £100,000. In July, 1869, this capital had been carried to £8,210,620, and in January, 1881, it had further grown to £16,000,000. At the present time it amounts to £17,239,970. The Company has also now a bonded debt of £3,877,706.

Telegraphic Communication with Lighthouses and Lightships.—In our issue of January 1st we printed some extracts from a letter on this subject which had been sent to *The Times*, by Mr. R. S. Culley. The following is extracted from a letter of Mr. E. Stallibrass, which appeared in Tuesday's *Times*:—"I have no hesitation in saying that, should money be forthcoming for the most important work of establishing communication with our isolated rock lighthouses, there will be no lack of engineers competent to successfully utilise it. It must be apparent to everyone that the difficulties are in no way comparable with those which were successfully overcome by Winstanley, Rudyerd, Walker, Stephenson, Douglas, and others by the construction of the very lighthouses with which it has become so important to establish telegraph communication. There has been, up to now, but one single attempt made, which resulted in failure. Are we to assume from this that the thing is impracticable? It is unreasonable to expect an ordinary type of submarine cable, laid in the usual way, to last under the necessary very unfavourable conditions. The question is not one of weight of the cable, as Mr. Culley thinks, but of specific gravity. Besides employing a type which will offer little resistance to the waves, in proportion to its weight in water, special means must be taken to secure the cable to the rocks. It would be advisable to lay down three or four specially-designed cables on the most sheltered sides of the rock, securing each one separately, but bringing their ends together and joining them to one main cable of ordinary construction at the first favourable spot clear of rocks. It is very unlikely that all these cables would be broken together, and so long as one lasted communication could be kept up."

The Municipal Station at the Halles.—Municipal electric lighting enterprise meets with but scant support in Paris, and if the following statistics, which recently appeared in the *Bulletin International de l'Electricité*, are to be relied on, the reason is not far to seek. The municipal station at the Halles Centrales has a plant capacity of 3,840 kilowatts, 1,075 kilowatts, or 36 per cent., being devoted to public lighting purposes. The financial outgoings and incomings for the first six months of 1891 were as follows:—Expenses: Wages, £1,837; coal and coke (881 and 1,268 tons respectively), £3,284; oil and grease, &c., £437; repairs, £594; total, £6,152. Doubling this we get £12,304 for the year, say £12,600 in round figures. The sales of current come out as shown below:—

Low-pressure system.	Kilowatt hours.		£
Halles Centralles	213,160	.....	6,054
Customers	24,725	.....	1,483
High-pressure system.			
Customers	17,067	.....	1,024
Belle Jardinière	81,583	.....	1,600
Totals	336,535	.....	10,161

Doubling these figures we have totals for the year of 673,070 kilowatt hours and £20,322. In the last municipal budget, however, the accounts showed an apparent profit of £10,216. In the receipts the municipal electricity is charged for at the rate of 1fr. per kilowatt-hour, although the companies only charge the city 71 centimes, so that the receipts are unduly swollen. On the other hand, to station expenses must be added, rent, interest, sinking fund, &c., and these bring up the total outgoings to £19,103. The capital expenditure is £45,200. The cost of production of the kilowatt-hour is 48 centimes, and the total cost comes out at 80·5 centimes, yet current is supplied by contract to La Belle Jardinière for £3,200, which corresponds to 49 centimes per kilowatt-hour, or an annual loss of £2,020.

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THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 251.*)

§ 50. **The Electrodynamometer.**—This instrument, in one or other of its forms, has been of so great assistance in the progress of electromagnetic science that it clearly demands a place in any description of apparatus for the measurement of currents. We shall, therefore, give a brief account of the principles on which the instrument works, and will deal first with the simplest possible case.

Take a large coil of radius A cm. and suspend at its centre a small coil of radius a cm. by a bifilar suspension, the planes of both coils being vertical (Fig. 44). The two wires of the suspension serve also to convey the current to and from the suspended coil. Let a current i flow round both coils. Let the normal position of the suspended coil (*i.e.*, when no current passes) be that in which its plane is at right angles to that of the fixed coil. The fixed coil is placed with its plane in the magnetic meridian. Let ϕ be the angle through which at any time the plane of the suspended coil has turned from its original position. The motion is, of course, in azimuth, *i.e.*, about a vertical axis.

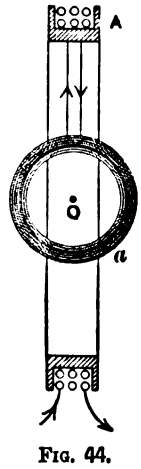

FIG. 44.

Let G be the "galvanometer constant" of the large coil; G is the magnetic force at the centre of the coil when the current in it is unit current. Let g be the sum of the areas of all the windings upon the small coil. Now when a current of strength i flows round the small coil, we can replace each turn of wire by a uniform magnetic shell of "strength" i, as was proved in § 23. Hence the total magnetic moment is $g\,i$. Now we suppose that A is so large compared with a that we may regard the magnetic field produced by a current i in A as sensibly uniform throughout the sphere, of which the circle a is a meridian, and accordingly the same as at the centre of A. The magnetic force at the centre of A is $G\,i$, so that by § 6, when the suspended coil has been turned round through an angle ϕ, the couple due to the large coil which is experienced by the small one is $i^2\,G\,g\cos\phi$ ergs, since the angle between the magnetic axis and the magnetic force is $\pi/2-\phi$. The direction in which this couple tends to turn the coil depends upon the direction of the currents in the two coils, and can be easily understood by referring to §§ 6, 22. The unit couple is such that its moment is equal to the moment of a force of one dyne, about a point, which is one centimetre distant from the line of action of the force. Since the "product" of a centimetre and a dyne is an erg, we may appropriately measure couples in terms of ergs.

Besides the couple due to the large coil, the suspended coil experiences a couple due to the action of the earth. The moment of this couple is $g\,i\,\mathsf{H}\sin\phi$, where H is the strength of the earth's horizontal magnetic field. The action of the bifilar suspension provides a restoring couple of moment $\mu\sin\phi$ ergs, where μ is a constant depending upon the length of the suspending wires, their distance apart and the mass of the suspended coil. Thus, when the suspended coil is in equilibrium under the action of these three couples, we must have

$$i^2\,G\,g\cos\phi = i\,g\,\mathsf{H}\sin\phi + \mu\sin\phi,$$

whence $$\tan\phi = i^2\,G\,g/(i\,g\,\mathsf{H}+\mu).$$

Now the instrument is always arranged and used, so that $i\,g\,\mathsf{H}$ is small compared with μ, so that on expanding this expression by the binomial theorem as far as the second term we find

$$\tan\phi = \frac{i^2\,G\,g}{\mu}\left(1+\frac{i\,\mathsf{H}\,g}{\mu}\right)^{-1} = \frac{i^2\,G\,g}{\mu} - \frac{i^3\,\mathsf{H}\,G\,g^2}{\mu^2}.$$

Let us denote this value of ϕ by ϕ_1. Now reverse the current in both coils, we shall obtain a value of ϕ of the same sign as before, but slightly different in value, thus

$$\tan\phi_2 = i^2\,G\,g/\mu + i^3\,\mathsf{H}\,G\,g^2/\mu^2.$$

Hence by addition we find $\tan\phi_1+\tan\phi_2 = 2\,i^2\,G\,g/\mu$, or

$$i^2 = (\tan\phi_1+\tan\phi_2)\,\mu/2\,G\,g.$$

If we had taken two other readings by reversing the current in first one and then the other of the two fixed coils we should have got two nearly equal values of ϕ, viz., ϕ_3 and ϕ_4, of the opposite sign to ϕ_1 and ϕ_2. Combining these with ϕ_1 and ϕ_2 we should eliminate any error which would arise from the imperfect perpendicularity of the two coils when no current flows through the instrument. Hence we have finally

$$i^2 = (\tan\phi_1+\tan\phi_2-\tan\phi_3-\tan\phi_4)\,\mu/4\,G\,g.$$

The values of ϕ are found in the usual way by attaching a mirror to the suspended coil and observing its deflection by means of a lamp and scale. If x is the deflection, and d the distance of the scale from the mirror, then $\tan\phi = x/2\,d$ approximately.

We must now consider how μ can be found. It is clear that the couple produced by a bifilar suspension is proportional to the mass, M, of the suspended coil. We may, therefore, write $\mu = \lambda\,M$. If T be the time of a complete vibration of the coil about a vertical axis, and K its moment of inertia, we have $T = 2\pi\sqrt{\frac{K}{\lambda M}}$. Now, fix to the suspended coil a bar whose moment of inertia, K′, can be accurately determined, and whose mass, M′, is known, and again observe the time of vibration. We have $T' = 2\pi\sqrt{\frac{K+K'}{\lambda(M+M')}}$. From these two equations we can find $\mu = \frac{4\pi^2\,K'\,M}{M(T'^2-T^2)+M'\,T'^2}$.

The only other quantities we have to determine are G and g Their values in the cases in which the two coils consist of a few turns of wire very close together are easily found. By § 28 we have $G = \frac{2\pi n}{A}$, where n is the number of turns on the large coil of radius A. To find g we remember that it is the sum of the areas of the windings of the small coil. Thus $g = \pi\,n'\,a^2$, n' being the number of turns, and a the mean radius.

§ 51. **Helmholtz's Arrangement.**—An essential point in the theory sketched out above is that the magnetic force at the centre of the small coil due to a current in the large coil should be very uniform. To gain this uniformity, the large coil is made in two halves, and placed with its two halves one on each side of the centre of the small coil. Let A be as before the radius of the coil, 2 B the distance between the two central planes of the two halves (Fig. 45). The problem before us is to find what value of B will make the magnetic force at O most nearly uniform. Let F_1 be the magnetic force due to one coil at a point P, whose distance from that coil is $B+x$, where x is small; then by Taylor's theorem

$$F_1 = F_0 + x\left(\frac{dF}{dx}\right)_0 + \frac{x^2}{1.2}\left(\frac{d^2F}{dx^2}\right)_0 + \ \ldots$$

where the suffixes indicate that in this equation we are to take the values of the quantities when $x=0$. Of course, x is put equal to zero *after* differentiation. If F_2 is the magnetic force

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due to the other coil when the current flows in the *same* direction as in the first coil, we have since the distance of P from the second coil is $B - x$.

$$F_2 = F_0 - x\left(\frac{dF}{dx}\right)_0 + \frac{x^2}{1.2}\left(\frac{d^2F}{dx^2}\right)_0 - \quad . \quad . \quad . \quad .$$

Thus for the whole magnetic force we have

$$F_1 + F_2 = 2\left\{F_0 + \frac{x^2}{1.2}\left(\frac{d^2F}{dx^2}\right)_0 + \frac{x^4}{1.2.3.4}\left(\frac{d^4F}{dx^4}\right)_0 + \quad . \quad .\right\}.$$

In order that $F_1 + F_2$ may be as nearly as possible independent of x we must have $\left(\frac{d^2F}{dx^2}\right)_0 = 0$. By referring to § 26, we find that $F = 2\pi A^2/\{A^2 + (B+x)^2\}^{\frac{3}{2}}$, so that

$$\frac{d^2F}{dx^2} = -\frac{6\pi A^2\{A^2 - 4(B+x)^2\}}{\{A^2 + (B+x)^2\}^{\frac{7}{2}}}.$$

Thus $\left(\frac{d^2F}{dx^2}\right)_0$ vanishes when $A^2 = 4B^2$, *i.e.*, when $B = A/2$, or the distance between the two coils is equal to their radius. This is called the Helmholtz arrangement. It is often made use of in the construction of tangent galvanometers, as it enables a larger magnet to be used than would be possible with a single central coil without serious error.

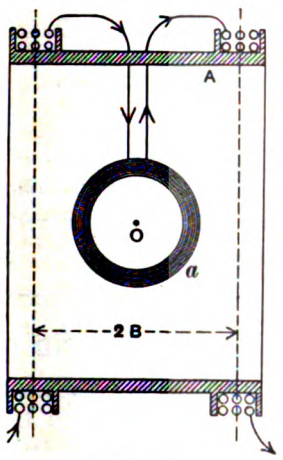

FIG. 45.

Now, the galvanometer constant G of the pair of coils is the value of the magnetic force at the centre of the system for unit current. If these are n turns on *each* of the large coils, we have $G = 4\pi n A^2/(A^2 + B^2)^{\frac{3}{2}}$. In the Helmholtz arrangement B is as nearly as possible equal to A/2, so that in this case we have nearly $G = 32\pi n/5\sqrt{5}\,A$. The diagram of lines of force for the Helmholtz arrangement given in Maxwell, Vol. II. (Fig. 19), shows how perfect is the uniformity of the magnetic field near the centre of the coil. A small correction must be applied to the above expression for G on account of the finite space occupied by the windings.

It is to be carefully noticed that B appears in the value of G, and that when B is nearly equal to A/2, the value of G is very much dependent upon that of B. In the case of the current-weigher, the value of the attraction was nearly independent of B when B = A/2.

The symbol g stands for the sum of the areas of the windings of the small coil. If a be the mean radius, *i.e.*, the radius from the axis to the centre of gravity of the windings, it can be easily found that

$$g = n'\pi a^2\{1 + h^2/12\,a^2\},$$

where n' is the number of turns and h the radial depth of the windings, supposed to be in a rectangular groove. Now it is impossible to determine a by measurement with any accuracy if there are many windings and the coil is small. A better method of procedure is to determine the ratio a/A by a method of comparison such as that of § 29, and to determine A by measurement of the large coil.

Neglecting for the present the small correcting terms, the complete expression for i^2, in terms of the quantities actually observed, is as follows :—

$$i^2 = \frac{x\,K'\,M'(A^2 + B^2)^{\frac{3}{2}}}{2\,d\,\{M\,(T'^2 - T^2) + M'\,T'^2\}\,n\,n'\,A^2\,a^2}.$$

The very appearance of this formula is enough to show that the electro-dynamometer as an instrument for accurate "absolute" measurements labours under many difficulties. Remembering that $K' = M'\,k'^2$, where k' is determined from the shape and size of the inertia bar, we see that the formula can be written

$$i^2 = \frac{\frac{x}{d}\left(1 + \frac{B^2}{A^2}\right)^{\frac{3}{2}}\cdot\frac{k'^2}{A^2}}{2\,n\,n'\left\{\left(\frac{T'^2}{T^2} - 1\right) + \frac{M'}{M}\cdot\frac{T'^2}{T^2}\right\}\frac{a^2}{A^2}}\cdot\frac{M'\,A.}{T^2}$$

The quantities we have to determine are—
the four ratios of lengths x/d, B/A, k'/A, a/A,
the ratio of the two masses M/M',
the ratio of the two times T'/T,
the two numbers n and n'*,

as well as the three quantities M', A and T. The quantities which appear in the form of ratios may be determined in terms of any convenient units, but M', A and T *must* be measured in Grammes, Centimetres, and Seconds. Since the square of a current is on the electro-magnetic system of the same dimensions as a force, it follows that in any determination with an instrument which measures the square of a current, we must of necessity determine in "absolute" C.-G. S. measure a Mass, a Length, and a Time. The best instrument will be that in which these three fundamental quantities are most easily determined with great accuracy.

(To be continued.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, January 15th.

JUNIOR ENGINEERING SOCIETY.

8 p.m. Ordinary Meeting. Paper to be read: "Modern Applications of Electricity to Metallurgy." By George C. V. Holmes, Sec. I.N.A.

SATURDAY, January 16th.

ASSOCIATION FOR THE IMPROVEMENT OF GEOMETRICAL TEACHING.

11 a.m. General Meeting at University College, London. Reports to be presented. Election of Officers.

2 p.m. Papers to be read: (1) "On Laguerre's Dictum concerning Direction." By Prof. R. W. Genese, M.A. (2) "On the Geometrical Interpretation of Fallacy in Elimination." By Prof. R. W. Genese, M.A. (3) "On the use of Horner's Method in Schools." By E. M. Langley, M.A.

TUESDAY, January 19th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed: "On Weighing Machines." By Wilfrid Airy, B.A., M.Inst.C.E.

WEDNESDAY, January 20th.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Annual Meeting. Election of Officers. Presidential Address by Baldwin Latham, M.Inst.C.E.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Spontaneous Ignition of Coal, and its Prevention." By Prof. Vivian B. Lewes.

FRIDAY, January 22nd.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "On the Driving of Electro-magnetic Vibrations by Electro-magnetic and Electrostatic Engines." By Prof. G. F. FitzGerald, F.R.S. (2) "On Supplementary Colours." By Prof. S. P. Thompson, F.R.S.

ROYAL INSTITUTION.

9 p.m. Evening discourse: "The Composition of Water." By Lord Rayleigh, F.R.S.

SATURDAY, January 23rd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Induction Coil and Alternate Current Transformers." By Dr. J. A. Fleming, M.A.

* The quantities n n' are the numbers of turns of wire upon each coil of the fixed system and on the moveable system respectively. The windings of any of these coils must be very carefully insulated from one another, since any defect in this respect is equivalent to a reduction in the number of turns.

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The Electrician.

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NOTICE.

With this week's Number is issued, as a Supplement, a **COLOURED MAP,** *showing the Electric Supply Mains laid in London up to January 1, 1892, together with the areas allotted to the different Supply Companies.*

ELECTRICAL EXHIBITIONS AND COMPETITION.

It may be confidently predicted that the Electrical Exhibition which was opened at the Crystal Palace on Saturday last will be a success. The first Electrical Exhibition in this country was held in the same building in 1882, and contributed in a very important degree to the progress of electrical engineering. The Paris Exhibition of 1881 was thoroughly international—no one could foresee its scope, and all who visited it were amazed at the already ripe condition of the industry. Electrical engineering was in a most critical condition; the air was full of new inventions, and the public were almost as eager as the scientific world to witness the beginning of a new art, and, we may say, a new feature of civilisation. The first Crystal Palace Exhibition was to a certain extent a *rechauffée* of the one at Paris. The Brockie arc lamps, worthy predecessors of the Brockie-Pell, the Lane-Fox, Maxim, and other glow-lamps, were highly appreciated by the public; the dynamos ran well and inspired confidence among engineers. The succeding Exhibition, in which an attempt was made to pit electricity against gas, though perhaps not so important as a landmark in the history of the subject, enabled many new dynamos and systems to be shown, but failed to establish any real rivalry, and at the present day, though we may compare prices and results, and while we believe that electric lighting will push its way as surely and as extensively as railway locomotion has done, it need not be said to rival or compete with gas any more than railways have competed with horses.

Competition in any industry is a good tonic, but a bad food. When competition becomes an incentive to production, energies and money must be fruitlessly wasted in the struggle. The dynamo practically created its own market; and the Paris and

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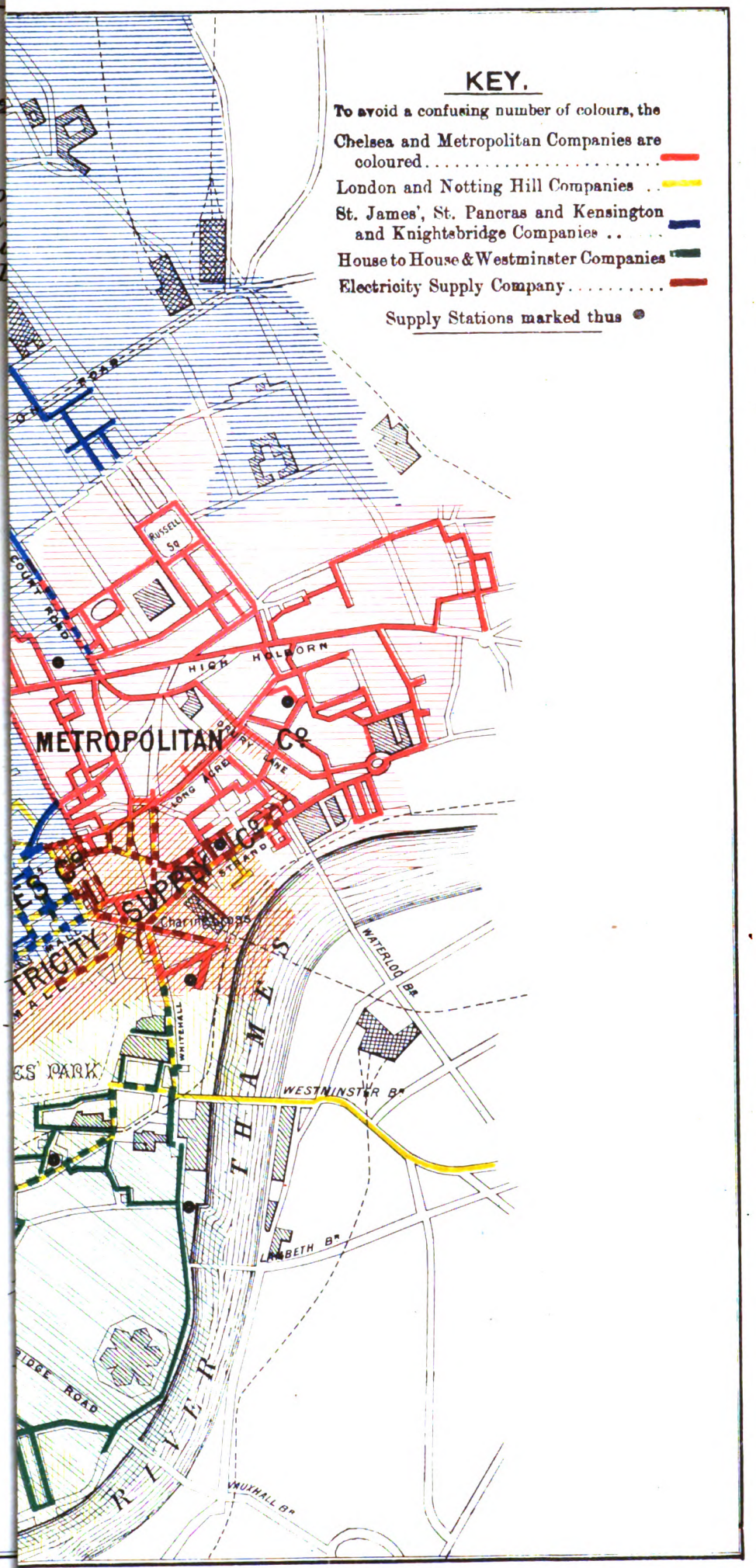

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Crystal Palace Exhibitions were the means by which this was effected. When it was shown what could be done, demand was naturally and healthily followed by supply; but, while competition has braced and invigorated the young trade, and has promoted the refinement and the development of high efficiency, it has at the same time left its mark upon the commercial side of the business. The stigma of rotten-company promotion was being branded on the industry even at the time of the first Crystal Palace Exhibition, and the very life-blood, viz., manufacturing profits, was soon affected; and it is to cut-throat competition that the inadequate return on electrical manufacture is solely due. We hear nothing now of the old cry that electric lighting will become popular when dynamos can be cheapened. Mechanical engineers and engine makers have had time to look into this question, and have been amazed that any one could make a business out of it. The evil side of competition is to be found in the office, and culminates in the enticing price list and the underbidding tender: the good side of competition ought be realised at an Exhibition, and should result in well-arranged tests. A committee of experts has been nominated for the Crystal Palace Exhibition, and we are determined not to be disappointed, for we expect no more from them than from similar committees in bygone Exhibitions—that is, nothing.

An Exhibition such as that which is now open, and which will be fairly complete in a week or two, is promoted with two entirely distinct objects; and, whether or no it achieves these, produces two other distinct results. The proprietors of the Crystal Palace want an entertainment which will draw, while exhibitors hope to increase their business. These objects have practically nothing in common, for the management imposes no commission on sales, as at picture galleries. The Crystal Palace Company may or may not, but probably will be, well rewarded by the shillings of the public, and other sources of profit; the exhibitors will surely book some orders, and might, if nobody else came near them, do good business among themselves. But, apart from these considerations, the public cannot fail to familiarise themselves with the possibilities of electric light and power, and the means by which these ends are attained; and the scientific and engineering world will not miss the opportunity of examining and comparing the *chefs d'œuvres* of dynamo and engine builders, and the countless objects with which the stands and show cases are filled. Our interest in the Exhibition is entirely confined to the last. If a dynamo has been described in our columns we have done with it, but the interest which the public may take in it is not diminished thereby. We intend to confine ourselves to the actual novelties and recent improvements which are to be found, and we have already found several that are well worth presenting to our readers. The old custom of filling columns at this time of the year with records of the past twelve months' work was bad enough; but to print all the descriptions which have been sent to us of exhibits which are perfectly well known to most of our readers would be worse.

Although electric lighting has been a prominent feature of many of the London Exhibitions of recent years, and while the engine-room never fails to attract sightseers, no extensive demonstration of the practical details has been offered for some time; and the public are sure to take this opportunity of investigating them, since most exhibitors provide attendants who can intelligently answer ordinary questions. An amusing change comes over the young man in charge during the progress of an Exhibition. During the first few days he will dart at any one who stops for a moment to look at his stand, or will even "buttonhole" a negligent passer-by. He will reel off a voluble account of the wonders of his wares, and descant on their capabilities. He will be staggered only for an instant if you ask him if he has anything new to show. By the end of the first week his spontaneous spoutings are spent, and he reserves his energies for inquirers. A month later his energies, too, have given out, and in reply to a polite inquiry, "What is a transformer?" he hands a circular, and no one but a possible customer can penetrate his taciturn abstraction. The remainder of the time till the close of the Exhibition is chiefly spent at lunch. If the competition between attendants could be maintained, each vieing with the other to offer intelligent explanations, the public could not fail to be greatly benefited. The technical visitors are interested almost exclusively in recent developments, new inventions, and the latest improvements. An engineer will take more interest in a brush-holder spring or the suspension of a galvanometer than in a row of half-a-dozen dynamos, which have been illustrated in price lists and advertisements for years past. It would be an excellent thing if on certain days the exhibitors themselves could attend, as many did on Friday last. Demonstrations and experiments on such occasions would be greatly appreciated, and the trouble would not be thrown away. Competition in such matters is eminently useful. No sooner do Messrs. Siemens Bros. arrange a 50,000-volt experiment, than Messrs. Swinburne and Co. propose a 100,000-volt set. But this sort of thing can be done all the more thoroughly the longer the interval between successive Exhibitions. An inverted Septennial, or better still Decennial, Act, forbidding the holding of Electrical Exhibitions under pain of attainder, except at stated periods, would be an all-round blessing.

ELECTROTECHNICAL NOTATIONS, ABBREVIATIONS, AND SYMBOLS.*

BY E. HOSPITALIER.

The question of the unification of electrotechnical notations, abbreviations, and symbols, is not absolutely new. In 1885 I brought it before the Société Internationale des Électriciens, and about the same date Prof. Andrew Jamieson did likewise at the Society of Telegraph Engineers. Reform is rendered all the more urgent by reason of the giant strides with which electrical applications have progressed within the last decade; it is difficult to follow them, especially in the case of communications from foreign countries. Is it possible at the present moment to obtain results useful to engineers and electrotechnical men, to create for them a sort of international symbolism, and a uniform, concrete, impersonal notation easily accessible to all? In a part, at least, of the domain of science and of the engineering art this symbolism already exists, and renders the greatest services; algebra, trigonometry, and the calculus have at the present day uniform symbols and notations, which are almost international, and are understood everywhere and by everyone. What has been done for the mathematical sciences can, in my opinion, be equally well done in the case of the physical sciences, provided we go to work methodically and resolutely.

The first and most indispensable point is to establish a clear and precise distinction between a *physical quantity*, its *magnitude*, and the *unit* which serves as a common measure in a given system to all magnitudes of the same kind. A physical formula always establishes a relation between physical *quantities*, each physical quantity being represented by a special *symbol*. The *magnitude* of a physical quantity is represented by the ratio between a physical quantity and the physical quantity of the same kind which is taken as unity. The magnitudes of physical quantities are, therefore, essentially abstract numbers. Finally, the *unit* is a physical quantity of a particular size, which serves as a common measure, multiple, or sub-multiple, to quantities of the same kind; which is designated by a special name, and which allows of abbreviations

* Abstract of a Paper read before the International Congress of Electricians, Frankfort, September 10, 1891.

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TABLE OF SYMBOLS OF PHYSICAL QUANTITIES AND OF ABBREVIATIONS.

Physical quantities.	Symbols.	Equations of definition.	Dimensions of physical quantities.	Names of the C.-G.-S. units.	Abbreviations of the names of the C.-G.-S. units.	Practical units.	Abbreviations of the practical units.
Length	L, l	...	L	Centimetre.	cm	Metre.	m
Mass	M	...	M	Gramme-mass.	g	Kilogramme-mass.	kg
Time (*)	T, t	...	T	Second.	s	Minute ; hour.	m ; h
Surface	S	$S = L.L$	L^2	Square centimetre.	cm^2	Square metre.	m^2
Volume	V	$V = L.L.L$	L^3	Cubic centimetre.	cm^3	Cubic metre.	m^3
Angle (†)	α	$\alpha = \frac{\text{arc}}{\text{radius}}$	A number	Radian.	...	Degree ; minute ; second ; grade.	...
Velocity	v	$v = \frac{L}{T}$	$L T^{-1}$	Centimetre per second.	cm/s	Metre per second.	m/s
Angular velocity	ω	$\omega = \frac{v}{L}$	T^{-1}	Radian per second.	...	Revolutions per minute.	t/m
Acceleration	A	$A = \frac{v}{T}$	$L T^{-2}$	Centimetre per second per second.	cm/s^2	Metre per second per second.	m/s^2
Force	F	$F = M.A$	$L M T^{-2}$	Dyne.	dyne	Gramme ; kilogramme.	g ; kg
Work	W	$W = F.L$	$L^2 M T^{-2}$	Erg.	erg	Kilogrammetre.	kgm
Power	P	$P = \frac{W}{T}$	$L^2 M T^{-3}$	Erg per second.	erg/s	Kilogrammetre per second.	kgm/s
Pressure	p	$p = \frac{F}{S}$	$L^{-1} M T^{-2}$	Dyne per square centimetre.	$dyne/cm^2$	Kilogrammme per sq. centimetre.	kg/cm^2
Moment of a couple	W	$F.L$	$L^2 M T^{-2}$	Dyne centimetre.	dyne . cm	Kilogrammetre.	kgm
Moment of inertia	K	$M.L^2$	$L^2 M$	Gramme-mass square centimetre.	$g . cm^2$	...	...
Intensity of pole	m	$F = \frac{m^2}{L^2}$	$L^{\frac{3}{2}} M^{\frac{1}{2}} T^{-1}$	...	...	...	...
Magnetic moment	$\mathfrak{M}$	$\mathfrak{M} = ml$	$L^{\frac{5}{2}} M^{\frac{1}{2}} T^{-1}$	...	..	...	...
Intensity of magnetisation	$\mathfrak{J}$	$\mathfrak{J} = \frac{m}{V}$	$L^{-\frac{1}{2}} M^{\frac{1}{2}} T^{-1}$	...	...	...	...
Intensity of field	H	$H = \frac{F}{m}$	$L^{-\frac{1}{2}} M^{\frac{1}{2}} T^{-1}$	...	...	...	...
Magnetic flux	ϕ	$\phi = H.S$	$L^{\frac{3}{2}} M^{\frac{1}{2}} T^{-1}$	...	...	..	...
Magnetic induction	$\mathfrak{B}$	$\mathfrak{B} = \mu \mathfrak{H}$	$L^{-\frac{1}{2}} M^{\frac{1}{2}} T^{-1}$	...	...	...	...
Resistance	R, r	$R = \frac{E}{I}$	$L T^{-1}$	...	...	Ohm.	o
Electromotive force	E	$E = RI$	$L^{\frac{3}{2}} M^{\frac{1}{2}} T^{-2}$	...	...	Volt.	v
Difference of potential	e	$e = RI$	$L^{\frac{3}{2}} M^{\frac{1}{2}} T^{-2}$	...	...	Volt.	v
Current	I	$I = \frac{E}{R}$	$L^{\frac{1}{2}} M^{\frac{1}{2}} T^{-1}$	...	...	Ampere.	A
Quantity of electricity	Q	$Q = IT$	$L^{\frac{1}{2}} M^{\frac{1}{2}}$	..	...	Coulomb ; ampere-hour.	c ; A . h
Capacity	C	$C = \frac{Q}{E}$	$L^{-1} T^2$	...	...	Farad.	F
Electric energy	W	$W = EIT$	$L^2 M T^{-2}$	...	...	Joule ; watt-hour.	J ; W . h
Electric power	P	$P = EI$	$L^2 M T^{-3}$	...	...	Watt.	W
Specific resistance	α	$\alpha = \frac{RS}{L}$	$L^2 T^{-1}$	...	...	Ohm-centimetre.	o . cm.
Conductivity (*conductance*)	...	$\frac{1}{R}$	$L^{-1} T$	...	...	Mho.	mho
Specific conductivity (‡)	...	$\frac{1}{\alpha}$	$L^{-2} T$	...	...	...	...
Coefficient of self-induction (*inductance*)	L_s	$L_s = \frac{\phi}{I}$	L	...	...	Quadrant or Henry.	Q or H
Coefficient of mutual induction	L_m	...	L	...	...	Quadrant or Henry.	Q or H
Magnetising force (§)	$\mathfrak{H}$	$\mathfrak{H} = \frac{4\pi NI}{L}$	$L^{-\frac{1}{2}} M^{\frac{1}{2}} T^{-1}$	...	...	...	...
Magnetomotive force	$\mathfrak{F}$	$\mathfrak{F} = 4\pi NI$	$L^{\frac{1}{2}} M^{\frac{1}{2}} T^{-1}$	...	...	Ampere-turn.	A . t
Magnetic resistance (*reluctance*)	$\mathfrak{R}$	$\mathfrak{R} = \rho \frac{L}{S}$	L^{-1}	...	...	...	...
Magnetic permeability	μ	$\mu = \frac{\mathfrak{B}}{\mathfrak{H}}$	A number	...	...	...	...
Magnetic susceptibility	κ	$\kappa = \frac{\mathfrak{J}}{\mathfrak{H}}$	A number	...	...	...	...
Specific magnetic resistance (‡)	ρ	$\rho = \frac{1}{\mu}$	A number	...	...	...	...

The C.-G.-S. magnetic and electro-magnetic units have not as yet received special names. They are designated by following the formula with the phrase C.-G.S. units.

No abbreviations.

(*) The International Bureau of Weights and Measures draws an important distinction in time notation, according as it is a question of fixing the *epoch* or the *duration* of a phenomenon. In the former case *superiors* are used, in the second the notation ranges. Example : The experiment began at $2^{h.}\,15^{m.}\,46^{s.}$, and lasted 2h. 15m. 46s., terminating at $4^{h.}\,31^{m.}\,36^{s.}$ I propose to follow this.

(†) The distinction between the different angular units (radians, degrees, minutes, seconds, grades, &c.), and their notations should be studied by a Geodesic Congress. I have no suggestion to offer.

(‡) Abbreviations to be made.

(§) *N* is the number of turns, *L* the length of the solenoid producing the magnetising force.

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intended to simplify speech or writing. The symbols of physical *quantities* enter into physical formulæ, but *units* never do. Thus, in the C.-G.-S. system, for example, the three fundamental quantities are length, mass, and time, their respective symbols being L, M, T; and the corresponding units are the centimetre, gramme, and second, abbreviated into cm., g, and s. If we take the derived units into consideration, we shall establish by successive definitions the equations connecting the symbols of these quantities and the relations between the units which serve as common measure to each of these magnitudes.

Let us take some examples. *Surface*, a derived geometrical quantity, the product of two lengths, denoted by the symbol S, will have the following equation of definition :—

$$S = L \times L = L^2 ;$$

the unit being the square centimetre represented by the abbreviation cm^2.

Volume, a derived geometrical quantity, the product of three lengths, denoted by the symbol V, will have as equation of definition—

$$V = L \times L \times L = L^3 ;$$

the unit being the cubic centimetre represented by the abbreviation cm^3.

Velocity, a derived mechanical unit, the quotient of a length by a time, denoted by the symbol v, will have the following equation of definition :—

$$v = \frac{L}{T} = LT^{-1} ;$$

the unit being the centimetre per second.

There is, therefore, some reason for observing an essential and definite distinction in the notation and writing of formulæ between the symbols representing physical quantities, and the units which serve as common measure to their magnitudes. With this object in view, italic, Greek and *ronde* type, &c., might be exclusively reserved for *symbols*, and Roman type for *units* and their abbreviations. A single symbol, always the same, might be allotted to each geometrical, physical or mechanical quantity, together with a special name to each corresponding unit. We should thus avoid the confusion of language, and sometimes of mind, at present existing with regard to force, power and work; resistance and specific resistance; specific induction and total induction, or flux of force, &c. The use of the same letter, to denote the same physical quantity, will permit of the rapid examination of the homogeneity and correctness of formulæ.

Owing to our lack of knowledge as to the absolute dimensions of physical quantities, and with a view of economising symbols, the same letter may be used to denote quantities of the same physical nature but of different dimensions, or different physical quantities having the same dimensions. Thus I propose, for instance, to denote by the symbol W, the physical quality called energy, whether this energy be mechanical (work), thermic (heat), or chemical or electrical affinity. I represent by the same symbol the moment of a force or the moment of a couple, since this moment, the product of a force and a length, is homogeneous with work. A length and a coefficient of self-induction have the same dimensions (the coefficient of self-induction being defined in the electro-magnetic system) and will be represented by the same symbol L, an index being added in some instances to avoid confusion.

The name of each compound unit can be formed in the same way as the dimensions of the physical quantity to which the unit is to serve as common measure, conforming to the rules laid down by the International Committee of Weights and Measures, and extending these rules to units in which quotients figure. These rules consist in adopting a small Roman letter for each fundamental unit, and in using a prefix to denote the multiples and sub-multiples. The following are examples of the abbreviations adopted by this Committee :—

Centimetre... cm; square centimetre... cm^2; cubic centimetre... cm^3; centigramme... cg.

Together with M. Ch. Ed. Guillaume I propose to extend the use of the prefixes adopted by the Committee, and to adopt the two following *provisionally*.

M—mega—1,000,000

μ—micro—$\frac{1}{1,000,000}$

For example, the megagramme would be written...Mg; the microgramme would be written...μg.

In cases where there are quotients several notations are possible. Thus the C.-G.-S. unit of velocity is the centimetre per second, which may be correctly expressed in six different ways : centimetre per second, $\frac{\text{centimetre}}{\text{second}}$, $\frac{\text{cm}}{\text{s}}$, cm : s, $cm.s^{-1}$ cm/s. The notations (cm : s), ($cm.s^{-1}$), and (cm/s) seem to me equally correct. The last being the quickest, I propose to adopt it as the type of similar units. Thus, the industrial unit of pressure, the kilogramme per square centimetre, would be written kg/cm^2.

The choice of the symbols to be adopted is a more delicate question. The work should be confided to a special committee, or another Congress should be called before definitely settling the matter. I will content myself with giving a table,* subject to revision and modification, of the notations, symbols, and abbreviations which I propose for the most important quantities and units which concern the electrical engineer.

A committee† was appointed by the Congress to consider this communication, and the following resolutions were proposed and adopted unanimously at the last meeting of the Congress on September 12, 1891 :—

A. The Congress resolves that :

(1) Physical magnitudes shall be represented by Italic letters. (Proposed by M. Hospitalier.)

(2) Units shall be expressed in Roman type. (Proposed by M. Hospitalier.)

(3) Physical constants and angles by Greek letters. (Proposed by Mr. Preece.)

B. The Congress resolves that :—While recognising the following designations—*watt* for the volt-ampere, and *joule* for the volt-ampere-second, names agreed to by the International Congress of Electricians held in Paris in 1889, the practical electrical units shall be represented by the initial Roman capital letters of their respective names."‡

A ..... Ampere	O ..... Ohm
C ..... Coulomb	V ..... Volt
F ..... Farad	W ..... Watt
J ..... Joule	

C. M. Hospitalier having drawn up a system of notation, which, in his opinion, would be capable of denoting all important practical physical quantities without causing any considerable modification in present usages, we invite the members of the committee nominated by the Congress to be so good as to examine this system, which the committee recommends in a general manner, to put it to a practical test, and to publish as promptly as possible in the technical papers the results of this investigation, with a view to a common understanding, leaving to the next Congress the definite settlement of the notations to be adopted.

THE LAST OF THE "GREAT EASTERN."

The "Great Eastern" was built in 1853-59 by Mr. Scott Russell at Millwall, in the Isle of Dogs, from the designs of Mr. Isambard Brunel. The problem Brunel had been set to solve was the construction of a steamer large enough to carry sufficient coal for a voyage to India and back; coal which could be bought in England for less than £1 a ton costing £5 at the Cape. For this purpose he designed a vessel 680ft. long, 83ft broad, 114ft. broad over the paddle-boxes, 58ft. moulded depth,

* This table has been modified in conformity with the resolutions of the Congress.

† The committee nominated at the meeting of the Congress on the 10th of September consisted of Prof. Ferraris (President), Profs. Ayrton, Eric Gérard, Hospitalier, Kohlrausch, Lowenherz, Nichols, Quincke, Roïti, and Silvanus Thompson, Herr Strecker, and Mr. Preece; secretary, Mr. Carl Hering.

‡ The recognition of the watt and joule was due to a proposal of M. Hospitalier. The employment of initial capitals as abbreviations of the electrical units was proposed by Prof. Roïti.

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and 18,915 tons gross register, to be propelled with both screw and paddles, and with a combined nominal horse-power of 3,000. The original plans were destroyed in the fire which occurred at Mr. Scott Russell's yard, and the actual dimensions of the ship were finally as follows:—Length, 693ft.; breadth, 83ft.; breadth over paddle-boxes, 120ft.; moulded depth, 58ft.; gross tonnage 22,500; registered tonnage, 13,335. On November 3, 1857, an attempt was made to launch her. This did not succeed, and for three months she defied all attempts to get her off the slips. At last, on January 31, 1858, she was successfully launched, broadside on, into the Thames.

Mr. Scott Russell adopted his wave line principle for the lines of the vessel, but to Mr. Brunel is due the idea of constructing her on the cellular system. She was built throughout of the best quality Lowmoor iron. The interior of the ship and the cellular hull were each divided into eleven separate water-tight compartments. The holds below the lower deck contained the machinery, boilers, stores, and coal; and

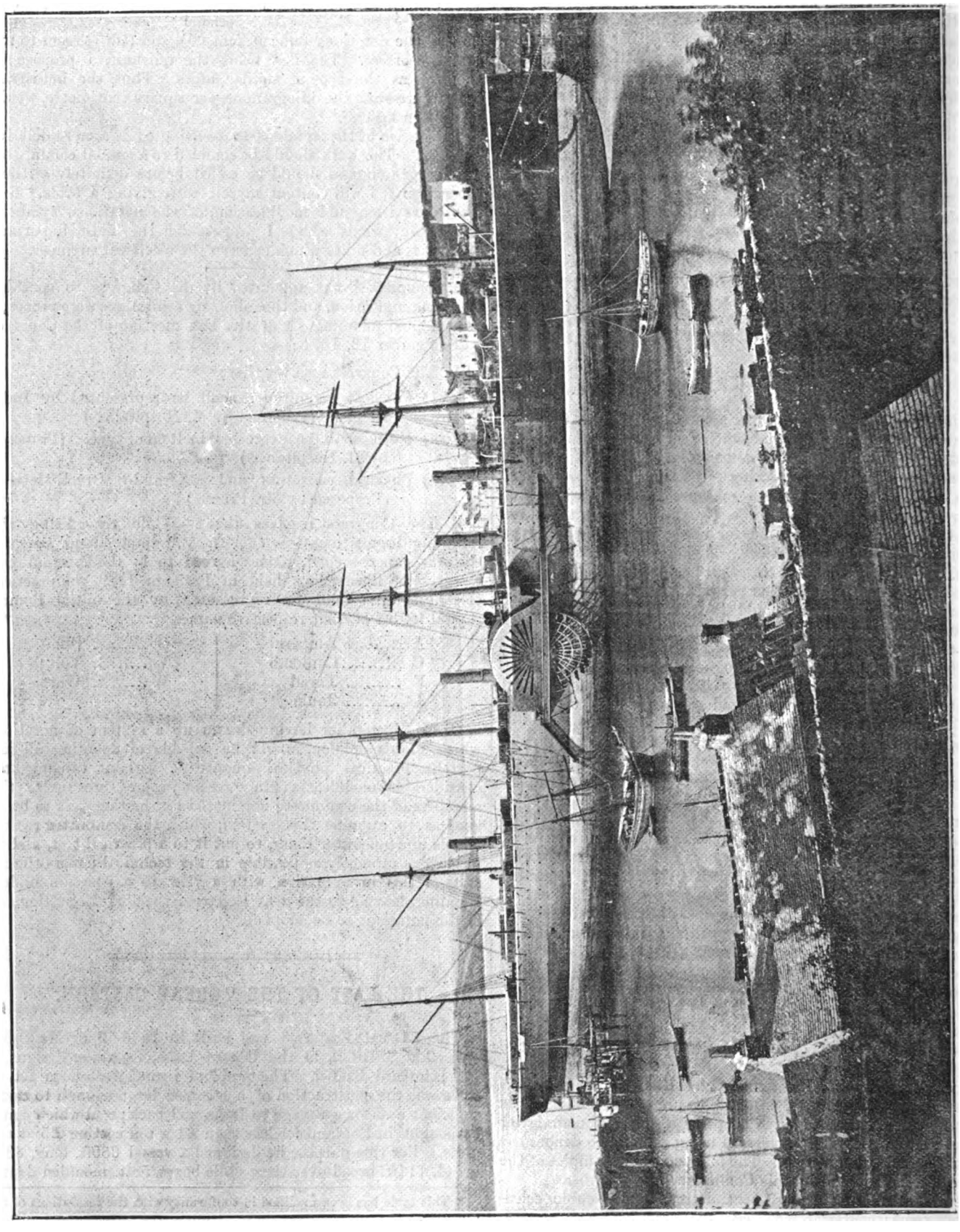

Fig 1.—The "Great Eastern" in Milford Haven, 1861.

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the upper part, three tiers of decks all fore and aft, was appropriated for passengers, the lowest of these decks being about 6ft. above the water-line. The cylinders of the oscillating paddle engines were four in number, 74in. in diameter, 14ft. stroke. The paddle-wheels were 56ft. in diameter, and steam for these engines was supplied from four double-ended tubular boilers, containing 39 tons of water, and provided with 40 furnaces. The chimneys were only 6ft. in diameter, but being 100ft. high above the grate bars, there was an excellent draught. The cylinders of the screw engines were also four in number, 84in. in diameter, 48in. stroke. The propeller was four-bladed, 24ft. in diameter. Steam was supplied to these engines by six tubular boilers with 60 furnaces. The working pressure was 25lb. per square inch. Her calculated speed was 15 knots per hour. She was designed to carry 4,000 passengers, 5,000 tons of cargo, and 10,000 tons of coal, and if fitted up to carry troops alone she had accommodation for 10,000. The total weight of ship and engines was over 12,000 tons, and when fully laden with passengers, cargo, and coal, she would weigh 27,000 tons, and be at a draught of 30ft. She had five funnels and six masts.

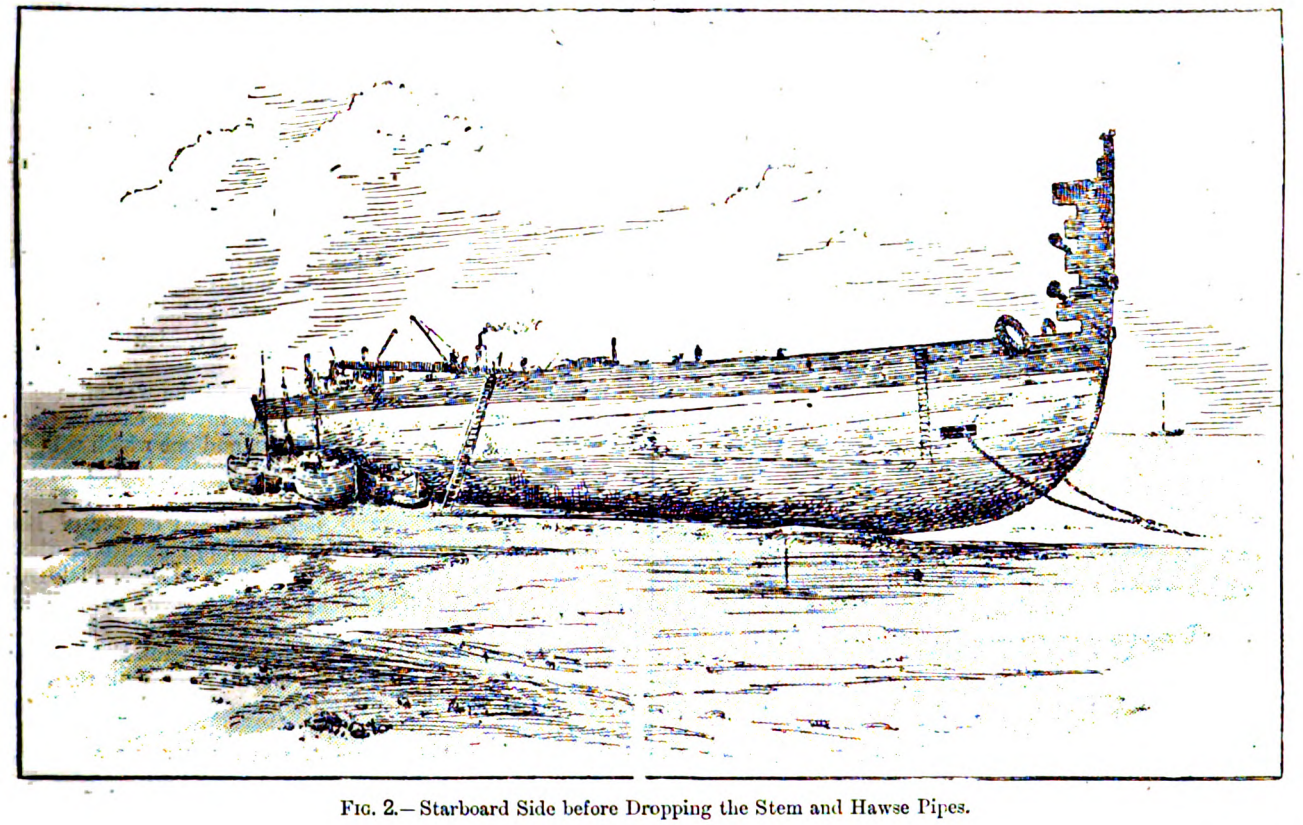

Fig. 2.—Starboard Side before Dropping the Stem and Hawse Pipes.

In June, 1860, she made her first ocean voyage to America, chiefly as a show ship, for she only carried 42 passengers out and 68 home. This voyage was a failure financially, although over 190,000 persons paid to visit her.

She was laid up at Milford Haven during the winter of 1860 61, and in the summer of 1861 she made several Atlantic trips, being finally much knocked about in a gale. She was then again laid up at Milford Haven during the winter, and made several runs between Liverpool and New York during the summer of 1862. In August of that year, on her voyage out, she struck on a rock off Montauk Point, the accident fully demonstrating the value and safety of the cellular principle of construction. In the summer of 1863 she made several voyages between Liverpool and New York.

Immediately after the formation of the Telegraph Construction and Maintenance Company, with Mr., now Sir, John Pender as chairman, its Directors offered to make and lay an Atlantic cable. The Atlantic Telegraph Company accepted their terms, and a contract was signed on May 9, 1864. The "Great Eastern" was chartered to carry the cable; and on July 15, 1865, left Sheerness for Valentia, under the command of Captain, now Sir, James Anderson. Mr. H. C Halpin was chief officer. Mr., now Sir, Samuel Canning was in charge of the expedition, and Mr. de Sauty was at the head of the electrical department, having Mr. Saunders as chief assistant. Mr. George Beckwith was her chief engineer. Prof. Thomson and Mr. C. F. Varley represented the Atlantic Telegraph Company, and Mr. Willoughby Smith the Telegraph Construction and Maintenance Company. On Sunday, July 23rd, the shore-end and intermediate having been laid by the "Caroline" and splices effected, paying out was commenced at six in the evening. As the cable was paid out several faults were discovered and remedied. On August 2nd, whilst picking up to recover a fault the cable fouled the ship and parted, 1,214 knots having been paid out at the time. After nine days of fruitless endeavours to regain the cable the "Great Eastern" was headed for home; and on August 20th anchored off Sheerness. A new length of cable was forthwith commenced, and on March 1, 1866, a fresh agreement was signed. On June 30, 1866, the "Great Eastern" left the mouth of the Thames again, under the command of Captain Anderson; and amongst those on board were Mr. Cyrus Field, Mr. (the late Sir) Daniel Gooch, Mr. Philip Rawson, and Captain Hamilton. On Friday, July 13th, paying out commenced; and on Friday, July 27th, the "Great Eastern" ran into Heart's Content Bay, and the first successful Atlantic cable was laid.

In 1868 the "Great Eastern" laid a telegraph cable from Brest to St. Pierre; in 1869 an Indian cable; and in 1871, 1873, and 1874 she successfully laid other Atlantic cables, and thus closed the mercantile career of the largest vessel ever floated, without even an attempt at the voyage for which she was designed and built, at a cost of £750,000.

Milford Haven was her final resting place, and there she lay idle for twelve years. On page 278 we give a view of the ship as she lay in Milford where the docks are now. From 1885 to 1888 she was chartered as a show ship, and visited Liverpool, Dublin, and Greenock. In 1888 the owners, Bath and Sons, Swansea, decided to break her up at Liverpool, and sell her as old metal. On November 20 to 25, 1888, every piece of timber, rope, metal, and furniture in her was sold by auction.

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The work of breaking her up was begun in May, 1889. The task was completed on September 30, 1891, the operation occupying two years and four months.

We are indebted to our esteemed contemporary, *The Engineer*, for the loan of the blocks of Figs. 1 and 2, and for a large proportion of the text.

THE CRYSTAL PALACE ELECTRICAL EXHIBITION.

Although the machine-room and many of the stands in the naves were in a chaotic state on Friday last, the latter had been fairly well set in order on the following day, when the Electrical Exhibition was considered "open." We alluded last week to several exhibits which were already in a presentable state, and on a future occasion shall return to some of those which present special points of interest. One of the most prominent features of the machine-room is an 8-pole Kapp continuous-current 130 kw. dynamo, coupled to a Davey-Paxman triple-expansion engine. The arrangement recalls the 320 H.P. Schuckert dynamo at the Frankfort Exhibition. In the boiler-house is a new form of water-tube boiler by Davey-Paxman.

Many leading firms are conspicuous by their absence from the Exhibition. Messrs. Mather and Platt, the Silvertown Company, Paterson and Cooper, Allen, Holmes, Parsons, Goolden, Laurence, Scott and Co., Latimer Clark, Muirhead and Co., are among those who are either too busy, or have other doubtless good reasons, for saving themselves the expense and trouble of putting in an appearance. But quite as many unfamiliar names are to be found; and we hope that the young firms will find a reward for their efforts.

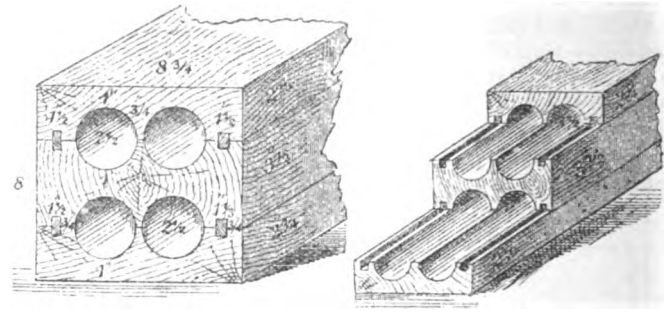
Messrs. Siemens Brothers are erecting five dynamos, of which four are to be driven by Willans engines. One of these is of the open type, built in accordance with the wishes of certain customers who think that what is out of sight is out of mind. While Messrs. Willans and Robinson cut away their casing, Mr. Raworth builds up oil guards, until at a superficial glance there begins to be a resemblance between the rivals. A very good show of gas engines will be found in the machine-room.

A very neat system of lubrication is to be seen at the Brush Electrical Engineering large stand in the South Nave. The pedestals of the dynamo are arranged as oil reservoirs, and supply two little rotary pumps, on the Root principle. These are driven from a light shaft mounted on the bed-plate, and belted to the dynamo shaft. The delivery pipes are led to the bearings, and supply both the top and the bottom of the journals by two separate pipes, provided with regulating valves. The oil is thus forced into the oil-ways under considerable pressure. The drain pipes lead from the bearings, and allow the oil to fall in a stream into cups attached to the side of the pedestals. A strainer is placed to receive the flow, and the oil passes back into the reservoir. "A visible drain" is thus substituted for a "visible feed," and the one is quite as satisfactory as the other for the purpose of ensuring a regular and continuous supply; but the "visible drain" has the great advantage that the lubricant can be forced into the bearings under pressure, this being impossible with a visible feed, unless the complication of more or less fragile glass tubes is resorted to.

The latest form of Mordey transformer differs only from the earlier patterns in the details of its mountings. Four terminals are provided for the secondary, which is wound with two similar circuits, thus allowing the consumer to take 100 volts or 50 volts. A switch is placed on the primary to enable fuses to be replaced. An ingenious "brush" is shown on an alternator. It consists of a long, limp, flat roll of wire gauze hung over the collector, making contact over a whole semi-circle. It is made fast to a terminal at one end, and the other is kept taut by a weight. These have not been largely employed by the Brush Company, but where they have been tried they work in a satisfactory manner.

Among the minor exhibits which were in a complete state on Friday last was that of the British Stone and Marble Company, who show numerous specimens of their Petrammite. This is a composition consisting almost entirely of silica, and resembling white china. The two important features of this material are—first, that it is a very good insulator, does not condense moisture on its surface, and is not affected by continued immersion in water; and, second, that it does not shrink, or warp, or twist in baking, like all porcelains. The material is moulded under pressure, and screws placed in the mould become surrounded with it, and thus excellent threads are produced, and accuracy of position of the holes may be ensured. Switch bases and lamp-holders of numerous patterns are shown.

Near the last exhibit are some specimens of the Macdonald conduit. The conduit is made of timber in lengths of about 14ft., with holes 2½in. in diameter. The sections, as shown in the illustration, are tongued with fillets, which, it is claimed,



keep out water. This conduit has been used for six years in Philadelphia. For telephone, and, possibly, for telegraph, work this conduit may be useful; but in this country it is doubtful whether it would be suitable for electric light work. Creosote is an admirable preservative for wood, but is most injurious to many kinds of insulating materials. Wood, treated in any way, is one of the worst materials for opposing a creeping discharge. Nor is this conduit suitable for use with lead-covered cables, since creosote attacks lead, and even alloys of tin are not entirely exempt from corrosion by the organic acids that are generated.

Whether there is much that is new in the way of machinery and apparatus can be discovered on further examination; an interesting feature of the Exhibition, and one which will, doubtless, be appreciated by the general public, is the display of ornamental fittings. In this department, again, there are many absentees. Where is the burnished copper of Benson, the massive brass work of Verity, or those gasfitters who have more recently turned their attention to electric fittings, such as Hulett and Strode? Why has M'Geoch, so well known in Glasgow, failed to tempt some London business? The Keys Company made a good show at the St. Pancras Exhibition; and no stand was more attractive on that occasion than that of Messrs. Crittall and Co., but they are not to be found even in the catalogue.

The catalogue is another feature of the Exhibition which ought to be thoroughly appreciated by sightseers. The exhibits are divided into sixteen sections, designated alphabetically, and each of these is prefaced by short, popular articles, which are the work of Mr. H. J. Dowsing. We have only one fault to find with it. We are sure that the article on "Electricity in Surgery and Therapeutics" would not have been allowed to pass without a word of warning against imposture, if the writer had known that it would be faced by a full-page advertisement of an impudent quack.

RADIATION OF ELECTRIC ENERGY.*

BY FRED. T. TROUTON.

The tendency of electric science has gradually been to more and more direct attention away from the wire in the case of electric currents to the surrounding medium as the primary seat of the phenomenon.

To start a current in a wire we now know really means to throw the medium occupying the surrounding space into some peculiar state, of the character of which we as yet know nothing for certain; but of the reality of this state, nevertheless, we feel

* The conclusion of a course of lectures delivered in Inverness, December, 1891, under the auspices of the "Ettle's Trust."

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sure, for one thing it requires energy initially to produce it, the amount necessary depending on the character of the medium and when the peculiar state ceases; or, as we say, when the current is stopped the energy, which has meanwhile remained stored in the surrounding medium, appears in an otherwise undue continuation of the current.

When the direction of a current is reversed we must suppose that there is something in this peculiar state of the medium which can be reversed, so that the medium surrounding a current must be affected with a definite directedness, or "set" of some kind in one direction, this "set" being reversed when the current is reversed. With alternating currents these reversals follow each other with regularity; and could we only see with our eyes what was going on in the surrounding medium, we would see the medium near the wire vibrate, first with a "set" along the wire in one direction, then in the other; next we would observe these disturbances spreading outwards from the wire one after the other into space, very much like what we see when we drop a stone into water. It is to the consideration of these electric waves we propose for the moment directing our attention. They constitute at the present time an important, though one of the latest branches of electricity. But before doing so it may perhaps be not amiss if we consider shortly the subject of waves in general.

It is quite a mistake to think that the medium itself travels forward with the waves. For instance, when waves pass over the surface of deep water, that is to say well away from the disturbing influence of the shore, the water moves up and down, but does not go forward. This may be seen to be the case by watching a small floating object; it moves up and down with the waves, but does not go forward. One can send waves along a stretched rope by oscillating one end, and here it is evident the only motion forward possible is that of the wave.

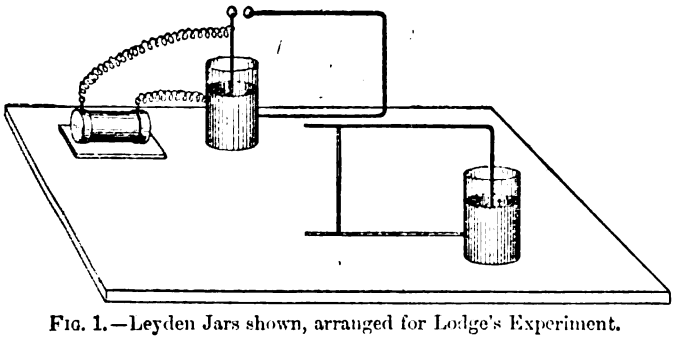

Fig. 1.—Leyden Jars shown, arranged for Lodge's Experiment.

The distance, apart of the wave crests, depends on how far a disturbance gets away before the next starts—that is to say, on the rate a wave travels. And since the rate is enormous, in the case of electric waves, the disturbances must succeed each other very rapidly, if the distance from crest to crest is to be small and at all within our capabilities of experimenting with. When the disturbances occur every second the distance from crest to crest is 180,000 miles, for that is the stupendous distance these electric waves are found to travel in one second.

The method at present employed for getting alternating currents of sufficient rapidity is well illustrated by the following experiment, due to Prof. O. Lodge (Fig. 1). In it the alternating current is obtained automatically, by utilising the natural tendency to oscillate to and fro, which a current in an incomplete circuit has. Such an arrangement can be produced through the following circumstances:—A considerable amount of electric energy, comparatively speaking, is able to be stored up by the device (now over a hundred years old) known as the "Leyden jar." It consists essentially of two metal plates placed near each other. This is effected in the Leyden jar by a coating of tinfoil on the outside and another on the inside of any ordinary glass vessel. Into such an arrangement a current can be run, and its energy kept stored there, apparently in some strain in the medium separating the metal plates. But as soon as the metal plates are connected by a wire, the stored energy is set loose in the generation of a current. This current will alternate, should the wire not be very long, and the resistance to the current not very great; and consequently the heat produced on the passage of the current in the wire be insufficient to completely account for all the energy stored in the jar. That is to say, the surplus energy will cause the current to overrun itself, and we will have the medium between the plates again strained almost as much as before, but in the opposite direction; again, there will be a current, but now in the opposite direction to the first one, and so on, the currents oscillating backwards and forwards until all the energy is exhausted, in this respect resembling the pendulum. The pendulum, when drawn up to one side and let go, will pass by the position of rest and over to the opposite side, provided the resistance to its motion is not too great, as it would be if the pendulum were placed, say, in treacle.

After this fashion, then, alternating currents of great rapidity are obtainable, by what may be considered an automatic arrangement, as contrasted with a dynamo; and at each rush of electricity from plate to plate, a wave starts out from the connecting wire and spreads outwards into space.

So much for the means employed for originating the electric waves; next we will consider how this radiation is to be received and detected. In fact, what is to be our electric eye, as Sir William Thomson calls it, which is to perceive these waves? It depends essentially on the principle of resonance. This principle is well illustrated by a common swing. When shoves are given to it at the right intervals, so as to suit the period of swing, the swing quickly starts up, absorbing energy each push. If it is pushed irregularly it is quite otherwise.

Two little swings of the same length (Fig. 2) suspended from either end of a horizontal rod illustrate this well; being of the

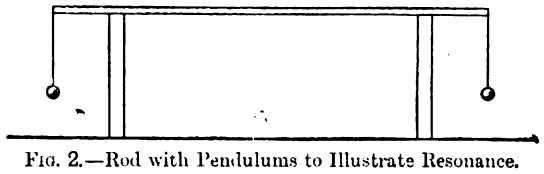

Fig. 2.—Rod with Pendulums to Illustrate Resonance.

same length they take the same time to complete each swing. Now if one of them be set going, we soon find the other beginning to swing also.

Each little jerk sent along the rod is just at the right interval after the last to give a help in getting up the swing. Now this obviously requires both to have the same period of swing; and, indeed, if we alter this by shortening or lengthening one of them, we soon see that the ability to absorb energy is destroyed—no swing is produced.

Thus we perceive that a receiver of the electric pulsations would be of the same size as the radiator. In Prof. O. Lodge's experiment, a jar of the same size as that of the radiator is used, the tinfoil coatings being joined up by a wire of the same length. So that, if we start the alternating currents in the radiator by charging up the jar till a spark occurs in the break left in its connecting wire, we know that the impulses it sends out are just at the right intervals apart to set our receiver also going; because the time which would be taken by the current to alternate is the same in both, and thus each successive impulse arrives at the receiving circuit just at the right instant to find a current going in the same direction as it would itself cause, the final result being a greatly-increased swing; so much so that the pressure in the jar increases sufficiently at last to cause quite a bright spark to pass from the little end of tinfoil projecting from the inside plate of the jar to the outside for the purpose. The necessity for the time of alternation being the same in both is seen on moving the vertical wire, which connects the two horizontal wires of the receiving jar to either right or left, for no spark can then be got in the little overflow path.

It was after this fashion that, four or five years ago, Prof. Hertz, of Bonn, constructed, for the first time, an electric radiator and receiver, and thereby gave us the means, and showed us how, to deal with electric radiations. Not that we knew nothing about electric radiations before then, for Maxwell had even calculated the speed they would be found to travel at; but until we could, so to speak, actually handle them, it necessarily remained outside the pale of experimental knowledge.

(To be continued.)

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LEGAL INTELLIGENCE.

National Telephone Company v. John Milne and Son.

In the Dundee Small Debt Court, on Tuesday, before Sheriff Campbell Smith, the National Telephone Company (Limited), Dundee, sued John Milne and Son, flour and provision merchants, Shore-terrace, Dundee, for £8. 10s., being the rent or subscription, payable in advance, for the year from November 15, 1891, to November 15, 1892, for the use of telephone wire and instrument. Mr. Robert Still, solicitor (Messrs. Thos. Thornton, Son and Co.), on behalf of the pursuers, stated that the defence advanced by the defenders was that sufficient service had not been rendered during the past year. That, however, was a defence which had been trumped up now that a disagreement had occurred between the parties. The lease, which he put in, was for three years, from November 24, 1890. About the month of October, 1891, John Milne and Son gave notice that they were to discontinue the use of the wire at Martinmas, 1891. It was intimated, however, by the Company that such notice could not be accepted, because the agreement was still current, and would not expire until Martinmas, 1893. In reply to that the defenders said, "We will not pay you another farthing. Every time we ask a connection it looks as if we were asking a favour, and this we have mentioned to your canvasser." The Telephone Company pointed out that any complaint which might have been made ought to have been made to the proper quarter, and it would have received the most careful consideration. Messrs. Milne in their next letter stated that "If you endeavour to coerce us to make payment for the wire we have now ceased to use, and for which no value could be rendered, it will be our purpose to let the facts be known through the Court by the public Press." That letter alone, Mr. Still contended, showed that there was an attempt on the part of the defenders to be vindictive, and he hoped his Lordship would not be a party to such vindictiveness. Mr. Still then read the conditions of leave between the Telephone Company and Messrs. Milne and Son, among which was the following:—"The Company shall not be liable for any loss or damage occasioned by the interruption of telephonic communication from any cause whatever."

Mr. URQUHART, for defenders, admitted that a contract had been entered into, but at the same time he declared that the service given by the Company to Messrs. Milne and Son had been radically bad. At times it was utterly impossible to get a connection through the Central Office with any other subscriber, and at the very period of the day when his clients most desired a connection with their customers they never could get it. The Telephone Company was very much afraid that the facts concerning the action should get into the daily papers. Mr. Urquhart said that Mr. Still had attempted to show that the complaints now put before the Court had been suddenly trumped up. That, however, was not the case. Messrs. John Milne and Son were large merchants, and had been in business for a great number of years. They had no wish whatever to get out of their obligations. More than that, it was of the utmost importance that a firm like theirs should have every facility they possibly could for communicating with their customers. It was simply and wholly because they could not get the necessary services out of the Company that they proposed to cease their connection with it. A telephone which gave bad service was of no practical use to them, and they objected to be blackmailed. The agreement was perfectly one-sided, being totally in favour of the Company. If he could prove that the pursuers had not got their part of the contract he thought his clients were quite at liberty to depart from their obligations in the matter. For a long time the service had been bad, and any attempt to get it improved failed. Instead of getting improved service they got a great deal of impertinence. It was quite a proverb in Dundee that the Telephone Company was responsible for half the profanity among the Dundee merchants. Mr. Urquhart said that Messrs. Milne and Son did not wish to deprive the National Telephone Company of their rights. There was an important clause in the agreement which allowed subscribers at the end of one year to give up the use of the telephone. That clause was as follows:—"The subscriber shall be entitled to cancel this agreement at the end of the first year on giving the Company six months' previous notice in writing, and paying an additional half-year's subscription." Mr. Urquhart contended that the Company had not got an efficient staff of servants. If the telephone were properly managed and the service complete, it would be a very valuable adjunct to his clients' business. Instead of the case being a trumped-up one on the part of Milne and Son, a considerable time ago—nearly nine months—they wrote to the Telephone Company saying that they had had at one time a mind to make the Telephone Company refund the money on account of the unsatisfactory service received.

The SHERIFF said the case raised a very difficult question. He doubted very much if it was a suitable one to be disposed of in the Small Debt Court. He could go far enough to be able to express an opinion from what he had heard that the case could not be disposed of that day. He was quite clearly of opinion that the case could not be disposed of without proof. In the first place, pursuers had no case without proof, because the documents signed by Milne and Son agreeing to be subscribers had been signed by one party, and such a document was not a contract by itself. It required proof that it was acted upon to make it a contract. The other part of the matter seemed to him to come to this, that Messrs. Milne and Son agreed to pay for the use of the wires for three years. They became dissatisfied because they could not get sufficient service, and they therefore wanted to get quit of the contract. The real case, therefore, that arose was whether the pursuers could prove a breach of contract against Milne and Son, or whether Milne and Son could prove a breach of contract on the part of the Telephone Company. If the Telephone Company could prove that Milne and Son had no more obstruction to the carrying out of their business by telephone than might be naturally expected, then the Telephone Company would succeed; but, on the other hand, if Messrs. Milne and Son could prove that the Telephone Company neglected to serve them—that they wilfully did it—and kept an insufficient staff, with the result that they could get no proper service, the case would assume a different complexion. His Lordship allowed proof, saying that he would fix a diet at an early date.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December* 31, 1891.

Block Signals.—The holidays have tended to make electrical news somewhat scarce. Perhaps the subject most immediately before the public mind is the application of electricity to block systems for railways. The terrible accident on the New York Central Railway a short distance from this city on Christmas Eve forced the matter of safety precautions on the unwilling attention of the officials of that road. The New York Central Railway has been experimenting for some time on various block systems, among them the Sykes, that of the Union Switch and Signal Company, and the Hall. The Sykes system is to be introduced, it is said, as far as Poughkeepsie immediately, and it is probable that one or both of the other systems mentioned will be installed beyond that point.

Storage Battery Traction.—The subject of electric road carriages seems to be agitating the fertile brains of some of our American inventors. Two separate attempts have recently been made—one in Chicago and the other in Boston—to put this particular sort of electrical traction into practical form, with the usual degree of success and improbability of any considerable results. *Apropos* of this, not very far out of New York, and on the main line of the Pennsylvania railroad, the traveller can see rising close along the side of the track a four-storey building, of imposing dimensions, crowned by a cupola; a great sign on the front bears the legend, "United Electric Company"; on an oval track immediately in front of it stand—forming their own funeral procession—the cars that have been taken off the Fourth Avenue line in this city. This lugubrious vision would deter most men from walking in a similar path, but it has not prevented the recent organisation of a Storage Battery Traction Company with half a million dollars capital.

The Green Electric Railway Patents.—We are beginning to hear a little more of the Green Electric Railway Patents, of which I wrote you some time since. That Green was one of the early workers in electric railroading is very certain; but from what can now be ascertained it seems probable that his invention followed closely in the line of the group of attempts at electric traction that date back to 1850. Few electricians attach any great importance to the patents for that reason. They may, however, have the effect of damaging what slight value some of the later broad patents might be supposed to possess. It does not seem that any more can be said for Green than that he was a most ingenious and persistent inventor, whose work serves as a connecting link between the electric railroad of to-day as elaborated largely by Siemens, and those older experiments which are well-known to many electricians. Taken as a group, electric railway patents are rendered of questionable value in view of the fact that so many experiments on the subject were made long before the invention of the dynamo.

Institution of Civil Engineers.—Saturday, January 2, was the 74th anniversary of the establishment of the Institution of Civil Engineers. Founded by six young men then beginning their engineering life, it has grown to be one of the largest bodies in the Kingdom, numbering 6,139 of all classes. In the Royal Charter of Incorporation, granted to the Society in 1828, its object was stated to be for the general advancement of mechanical science, more particularly in its application to civil engineering.—Amongst the Associate Members elected at the ordinary meeting on Tuesday last was Mr. H. J. S. Heather, B.A.

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CORRESPONDENCE.

SOME EXPERIMENTS ON SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue you gave a short account of some experiments on secondary batteries as made by Mr. Robertson, the results of which seem dubious to me, on the ground that the working admits a considerable source of error.

From your account it appears that you used a low-resistance voltmeter, an instrument which would require a fairly large current. This is no objection when used with ordinary large accumulators, since they, having a very low resistance, will supply the required current, and yet give a potential difference practically equal to the E.M.F.

But when the same current is taken from a miniature cell, whose resistance is far higher, there is a great danger that the potential difference will differ appreciably from the E.M.F.

Nor is this all. The "capacity" (or power to maintain a current) of such a miniature cell is very small, so that it soon runs down if the current exceeds a certain value.

It seems to me that these facts account for most of the results given; but as I am merely surmising, I only point out three things:—

1. All the E.M.F.'s given are low.
2. The cells seem to run down almost at once in all trials.
3. That in trial of cell B the addition of hydrogen dioxide does not at first reduce E.M.F., but only when the current has been running a short time.

These three agree with what I should expect if my suggestion be true. I have worked with cells for many years, and never got E.M.F.'s so low as those quoted unless the cell was in need of "charging."—Yours, &c., W. HIBBERT.

14, Goldhurst-terrace East, South Hampstead, N.W.,
January 7, 1892.

P.S.—Dr. Gladstone and I hope to read a Paper on the E.M.F. of such cells at the next meeting of the Physical Society. Our results are practically in direct opposition to those obtained by Mr. Robertson.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Hibbert has favoured me with the substance of his letter to you with reference to the experiments on secondary batteries described in your last issue; so I take the opportunity of replying at once.

My original experiments on the effect of hydrogen dioxide on E.M.F. were made with a Thomson high-resistance galvanometer, with considerably over a megohm in series with it; but one day, when repeating the experiments, I found, to my surprise, that, although, as Mr. Hibbert points out, small cells, on a low-resistance voltmeter, naturally ran down quickly, still the effect of hydrogen dioxide in hastening the running down was unmistakable.

With reference to the E.M.F., I have never calibrated the voltmeter for use with the small cells; but, judging by results obtained when using a galvanometer, I should say 1·7 divisions on the voltmeter was equivalent to about 1·9 volts.

The voltmeter was only used to get a deflection, and I think Mr. Hibbert leaves out of consideration that, though cell C contained two lead plates, it was only the E.M.F. of the couple formed by the interchanged plates which was annulled, that of the other lead plate and the positive remaining much what it had been until these plates were interchanged, when it fell immediately as before.—Yours, &c.,

G. H. ROBERTSON.

30, Hemstall-road, West Hampstead, N.W.

PLATINOID v. COPPER FOR D'ARSONVAL GALVANOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should hardly feel justified in trespassing any further upon your valuable space in the above question except for the fact that Mr. Mather in his reply to my previous letter makes a few statements, which, to the ordinary reader, must give an incorrect impression of the working of the system of measuring instruments at Thames Ditton, and which therefore call for a few words of explanation. I have namely shown that the existing copper coil in the ampere-galvanometer involves variations of resistances of ·04 per cent per °C. only, when currents of 200 amperes and upwards are measured (of course, by far the greater part of the work falls within this range), and since ·023 per cent. of this is balanced by the main rheostat, the errors that could occur *in the scale-readings* would not exceed ·017 per cent. per °C. if the proper corrections for temperature were neglected altogether. I have further pointed out that, with the platinoid coil proposed by Mr. Mather, the value of the galvanometer-current corresponding to any given deflection, on the determination of which all the measurements depend, and which is now found with extremely great accuracy (·011 per cent. + the error in the observation of the deflection), could be only roughly measured. According to the resistance in the standard cells at present in use, the error in this measurement might become as great as ·14 per cent. Now, considering how small the trouble is to make the necessary correction for temperature, and remembering that the real measurement is quite independent of this correction, Mr. Mather's latest arguments have not made me alter the view I have already expressed. It is not a question of getting rid of temperature-corrections altogether, and the proposed saving in labour would, as shown, be too dearly paid for.

My chief object, Sir, in again addressing you is, however, to point out that the real measurement in Captain Sankey's system is, for the amperes:—

$$C = \frac{R_A + G}{m R_1 + G} \frac{e}{B} \text{ (formula 2 in the Paper);}$$

and for the volts:

$$E = \frac{r}{r_a} \frac{R_v + G}{m R_1 + G} e \text{ (formula 4 in the Paper);}$$

and it is in these measurements we claim to work within $\frac{1}{5}$ per cent., and not in the ordinary scale readings as supposed by Mr. Mather; I am, therefore, not concerned with that part of his argument which is founded on the latter supposition, although I may say that I fully agree with him, that even the scale-reading alone, when care is taken, may come very near to the ·2 per cent. But, looking at formula 4, $R_v + G$ was the resistance of the galvanometer-circuit whilst the mean reading from the dynamo trial was obtained, $m R_1 + G$; the corresponding resistance when this mean reading was reproduced by the use of the standard cell (of E.M.F. $= e$), r/r_a is the relation between the total and a portion of the potentiometer-rheostat. Now, as the two fractions of resistances are obtained by bridge measurements, their product will be known within ·07 per cent.; and, allowing 1°C. as the maximum error in taking the temperature of the cell, in order to have the result within ·2 per cent., the errors of reading must be within ·05 per cent., which is easily possible. But with the platinoid coil the error in $R_1 + G$ might, as admitted by Mr. Mather, be ·14 per cent., which is more than we can afford.

Let me remind Mr. Mather, when he says, "It is no use calibrating an instrument to an accuracy immensely greater than that to which its scale can be read," that it is exceedingly troublesome to balance with a galvanometer, on which the smallest visible deflection covers the whole permissible error (unfortunately, with the platinoid coil, it would cover even a little more); it causes waste of time and ruin to the standard cell.

The error mentioned as ·4 per cent. in connection with the potentiometer-rheostat (the proportion r/r_a above) does not, as Mr. Mather says, apply with constants ·05 and ·1, but with the former only—applying to the range 1·7 to 8 volts. But in the real measurement (formula 4) it does not exist, for the resistance r_a is of course measured with the galvanometer-circuit closed, and thus the true fall of potential ascertained.

With reference to the danger, mentioned by me, of the heating of the resistance-coils in series with the platinoid coil on account of the comparatively heavy current used, I highly admire the exact way in which Mr. Mather has dealt with this question:

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The maximum heat produced in one coil (400 ohms) is ·7 calories per hour; weight of metal in coil, 56·7 grammes; hence 1°C. rise of temperature in 7¼ hours if no heat escaped.

One can, of course, have resistance-boxes made in which the metal of the 400-ohm coil weighs 56·7 grammes; but in the ordinary commercial patterns the weight of that metal (when in G.S.) is 4·3 grammes, 1°C. rise would be attained in $4{\cdot}3/56{\cdot}7 \times 7\frac{1}{4}$, *i.e.*, in 0·54 hour; and after making due allowance for the heat which will escape, we shall have enough left to more than balance the almost infinitesimal advantage introduced by the platinoid. Errors of the kind here mentioned should be strictly avoided, as they are very difficult to detect.

Mr. Mather has also dealt with the question of the weights of the two coils of different metals. His assumptions as to the actual properties of the existing copper coil are, however, incorrect, and the same is necessarily the case with the conclusions.—I am, &c.,

F. V. Andersen.

January 12, 1892.

THE ASSOCIATION FOR THE IMPROVEMENT OF GEOMETRICAL TEACHING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The new departure of the Association, to which I alluded at the close of my former letter, viz., the extension of the field of work to include all branches of Elementary Mathematics and Mathematical Physics, was not taken with the same unanimity which marked the proceedings, as long as they were confined to Elementary Geometry. Although most were ready to admit that there was much to be done both in reforming the methods now in use in teaching Arithmetic, Algebra, Trigonometry, and Dynamics, and in popularising the ideas of Maxwell and Clifford on *vectors*, it was doubted by some whether the organisation of the Association would be found suitable for the purposes advocated. The chief objection to the step was well put by one of its opponents (who, however, has continued to be one of the most loyal workers for the Association): "The great bond of union among them as an association was that they had a grievance—Euclid forced on them by the public examinations. If they extended their operations to subjects in which no grievance existed there would be so much diversity of view, and their efforts would be so far less definite that they would be scarcely likely to succeed in getting attention. . . . If they went into certain other subjects, they would not have common interests and common views."

Experience has shown that there was much force in these objections, though fortunately they did not prevent the proposed extension; and it will be instructive to examine how far the Association has been able to carry out its revised programme, which it was to effect—

(i.) by the reading of Papers or raising discussions at meetings of the Association;

(ii.) by the appointment of committees to report on existing defects in the usual methods, order, range, &c., in teaching special subjects, and the expediency of drawing up syllabuses or text-books of such subjects;

(iii.) by the drawing up of such syllabuses or text-books by committees or individuals selected by the Association.

In (i.) it has been fairly successful, as a glance at the following list of Papers published with the annual reports may show:—

1883. "The Teaching of Elementary Mechanics." (W. H. Besant.)
"Notes on the Teaching of Elementary Dynamics." (Prof. G. M. Minchin.)
"The Basis of Statics." (Prof. H. Lamb.)
1884. "The Discovery and the Geometrical Treatment of the Conic Sections." (Rev. C. Taylor.)
1885. "Elementary Mechanics." (Prof. R. W. Genese.)
1886. "The Correlation of the Various Branches of Elementary Mathematics." (R. B. Hayward.)
1887. "The Teaching of Modern Geometry." (Rev. G. Richardson.)
"The Modern Treatment of Maxima and Minima." (Rev. J. J. Milne.)
"Geometry from an Artist's Point of View." (G. A. Storey, A.R.A.)
"Note on the Nine Point Circle." (E. M. Langley.)
1888. "The Recent Geometry of the Triangle." (R. F. Davis.) With Notes by E. M. Langley, and R. Tucker.
"The Multiplication and Division of Concrete Quantities." (Prof. A. Lodge.) With notes by Mrs. Bryant.
"Some Principles of Arithmetic." (W. Bell.)
1889. "The Vices of our Scientific Education." (Prof. G. M. Minchin.)
"Horner's Method." (R. B. Hayward.)
1890. "A New Treatment of the Hyperbola." (Rev. C. Taylor.)
"The Teaching of Plane Trigonometry." (G. Heppel.)
"Some Geometrical Theorems." (E. M. Langley.)
"Statics and Geometry." (Prof. G. M. Minchin.)
"Isoscelian Hexagrams." (R. Tucker.)
1891. "On the Use of the Term 'Abstract' in Arithmetic." (Miss Wood.)
"The Foundations of Geometry." (E. T. Dixon.)
"Some Notes on 'Statics and Geometry.'" (E. M. Langley.)
"Sketch of the Life of the late A. J. Ellis." (R. Tucker.)

Of these, perhaps, the most interesting to the general reader would be Mr. Storey's, which gave an easy treatment of some of the simpler problems in perspective, and Mr. Davis's, which, I believe, introduced many of its readers for the first time to a connected view of an interesting group of recently discovered theorems, and showed that the triumphs of the older methods of geometry were not yet exhausted. But there is no doubt that the one which takes the most advanced views of future developments in mathematical teaching is that entitled "The Correlation of the Various Branches of Elementary Mathematics," by Mr. R. B. Hayward. This is, unfortunately, out of print and scarce. It goes far in the direction of some of the changes advocated, as I gather from the "notes," with editorial approval, by Mr. Heaviside. Perhaps, Sir, you might see your way to doing a service to the cause of progress by allowing a reprint of it to appear in your columns.

The work of the committees has, on the whole, been slow and unsatisfactory. Those for geometrical conics and for higher plane geometry completed their work with a fair amount of despatch. The former, though it contributes nothing to the method of teaching the subject, is a well-ordered sequence of propositions, which has been adopted by Messrs. Cockshott and Walters, as the basis of an excellent text-book (Macmillan). The latter supplies a good selection of elementary propositions, adapted for school use, in higher plane geometry, and is likely, I understand, to be also adopted as the basis of a text-book. But the divergence of views of members of the Committee on Mechanics has prevented much progress being made with its work, and that on solid has done very little beyond the circulation among members of a draft syllabus, which it seems impossible to get either mended or ended. To my own mind this method of bringing out syllabuses seems rather a costly mistake on the part of the Association; and that the Council would do well to abandon it on the completion of those now in progress, and to develop much more extensively the method, adopted on a small scale during the past year, of circulating pamphlets or fly-leaves in which individuals may bring before their fellow-members various points of mathematical teaching to which they wish to draw attention. The Association may thus long serve as a useful bond among mathematical teachers who wish to keep alive to every possible improvement, whether in such humble matters as a simpler presentation of some old-world theorem, or the introduction into school courses of methods made possible by recent developments of their science.

I should like to say a few words as to your remark on the "stubborn conventionalism of the modern schoolmaster, who pleads that he cannot make any change because of the Universities." I do not think the "modern" schoolmaster is more "conventional" than his predecessors, and I feel certain that he is less "stubborn." Unfortunately, his plea as to the Universities is only too sound a one, Oxford in particular issuing term by term in its pass geometry papers artistically finished specimens of what an examination in geometry should not be. These consist almost always of book work only, without a single question on the subject matter, and without a single exercise. It is to be hoped that the Council of the A. I. G. T. may bring some further influence to bear on the examining authorities, and endeavour to get Papers set more in accordance with the spirit of the report adopted by the Hebdomadal Council. At present the Papers are

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direct incentives to "cram" in its worst form. Nor is the evil confined to those students thus directly influenced. In the words of an Oxford graduate: "From the ranks of the passmen are recruited a large number of schoolmasters. That these men should receive, in an education professedly liberal, a mathematical training so inadequate in amount, and so imperfect in method, is to be regretted for their own sake; but still more so for the sake of those who may come under their educational influence. It is not to be expected that men who have never been compelled either to study elementary geometry intelligently, or to give more proof of their knowledge than is involved in the mechanical 'writing out' of propositions from memory should develop into good teachers of the subject. As they have learnt so will they teach—without interest and without intelligence." I used the words "consist *almost* always of book work;" a little while since the qualification might have been omitted, but there does occur a strange, almost portentous, innovation in the last Trinity Term "Smalls" Euclid Paper. At the end of the Paper, tacked on to I. 12, occurs the question, "*Why must the given straight line be of unlimited length?*" This really looks like a rift in the clouds; we may hope for brighter days; "c'est toujours avancer, que de faire un pas, quoiqu'il ne soit pas grand."

I conclude with a cordial invitation to those interested in our work to attend our afternoon meeting at University Colllege, to-morrow (January 16th) at 2 p.m.—Yours truly,

EDWARD M. LANGLEY, Hon. Sec., A.I.G.T.

16, Adelaide-square, Bedford.

"WHAT IS ELECTRICITY?"

TO THE EDITOR OF THE ELECTRICIAN.

SIR: That much-debated and apparently unanswerable question, "What is electricity?" having been once more raised in your columns, will you kindly allow me to draw attention to one or two points affecting this question?

You have already very ably replied to Dr. Molloy's letter in your issue of the 1st inst., and it must be evident to all that a comparison of work done by heat in falling from a higher to a lower temperature with water in falling from a higher to a lower level, and electricity in falling from a higher to a lower potential, which draws a distinction between the first and the two latter cases, on the ground that in the case of heat the work done is equivalent to the heat which has *disappeared*, whereas in the cases of the falling water and electric "current" there is no disappearance of water or electricity—is essentially wrong. In neither case is there a disappearance of anything—merely a transfer of motion.

But "What is an electric current?" is the question so often asked, and as often has the attempt been made to give a satisfactory explanation. We have had the older theory representing the electric current as conveyed *through* the conductor with its hydraulic analogue, and the modern view of the ether as the medium through which the transfer takes place, both ably championed, yet with no more apparent result than that of showing more clearly the weak points of both.

There is one point which seems to be much overlooked by both parties, viz., that the electrical transmission of energy *is a function of the ultimate particles of matter.*

That the electrical transmission of energy is in some way dependent upon the molecular constitution of the solid "conductor" is indisputable. Yet upholders of the modern views appear to argue their case of the ether as the active agent in such cases of energy transfer, quite regardless of the constitution of the solid "conductor." In fact, to all appearances, a rod of glass would suit their purpose as well as a rod of copper.

Those holding the older views and suppose an actual flow of something to take place in the conductor, or a propagation of energy by an end thrust or its equivalent, also seem to give little thought to the ultimate constitution of the conductor, and show no reason why such a flow should not take place equally well in the best insulator and the best conductor.

The mere assertion that the one is a conductor and the other an insulator seems to serve without further attempt at explanation.

We have no knowledge of electricity apart from matter; and this, to me, plainly indicates that it is to matter that we must look for a satisfactory explanation of the electric "current."—Yours, &c.,

WALLACE H. PAULL.

Handsworth, January 12, 1892.

STEAM-ENGINE ECONOMY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is said by one of your contemporaries in last week's issue that, in a report to the Portsmouth Town Council, Professor Garnett has stated that the Parsons turbo-generator is now "as efficient as the best compound engine of the marine type, and that for light loads it stands unequalled." The authority for these statements is said to be the report by Professor Ewing, F.R.S., published in your paper for last week.

Those interested in the "best compound engines of the marine type" (as electric light engines) will no doubt take care of their own credit; but the Continental users of direct-coupled condensing engines of this pattern will perhaps be surprised to hear that a plant which uses 27·6lb. of water per electrical H.P. per hour when working condensing is formally stated, in a report by the electrical expert of one of the most important English towns, to be as efficient as their own.

Our concern is with the statement that "for light loads it (the turbo-generator) stands unequalled." We beg to assure Prof. Garnett that there are no figures in Prof. Ewing's report which bear this out. At low temperatures the turbo-generator is, for obvious reasons, *relatively* a more efficient machine than an expansive steam-engine; but at no power quoted (not even at *no* electrical load—at which even an alternating station can hardly want to run) is the consumption nearly so low as that in the best Willans engines with direct-driven dynamos—of course, when working condensing. At full load the consumption of the turbo-generator reaches, as above stated, to 27·6lb. per E.H.P. hour, a figure usually surpassed by the Willans *non*-condensing engine. In many recent trials of a Willans condensing engine (of much smaller power than the turbo-generator tried at Newcastle; in fact, indicating only from 30 to 40 H.P.) the consumption per I.H.P. per hour has been about 12·8lb. of steam. With a combined efficiency of 80 per cent., which is the lowest we are accustomed to get with good dynamos, this corresponds with 16lb. per electrical H.P. per hour.

These figures, which are recent, are probably not known to Prof. Garnett; but Prof. Ewing's report speaks of published trials with a Willans engine, in which the consumption was about 25lb. per unit, or, say, 18·6lb. per electrical H.P. Yet Prof. Garnett totally ignores these figures from an actual engine (compared with which those of the turbo-generator are *about half as large again*, and makes comparison with nothing but an engine of a kind which no one in this country would be likely to use; whereas the Willans engine is used in England (for central stations) to the extent, probably, of 2 H.P. for every 1 H.P. of all other kinds of engines put together. Thus, in the comparative estimates stated to have been drawn up for the guidance of the town councillors, the cost of an installation of turbo-generators is compared with that—not of Willans engines, or of any other form of direct-driven plant—but with an absurdly obsolete plant consisting of engines "making not more than 90 revolutions per minute, coupled by endless rope-gearing to dynamos, making 300 revolutions per minute.—Yours, &c.,

WILLANS AND ROBINSON (Limited).

C. S. ESSEX, Secretary.

Picton House, Thames Ditton, Surrey,
Jan. 13, 1892.

THE CUTTRISS TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the description of the new Cuttriss telephone that you published in your issue for last week, the following extract from Prescott's Book on the Telephone, 1879 edition, page 545, is instructive:—

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"*Short-Circuiting Telephones.*—A spiral spring is wrapped round a cylinder, the diaphragm pressing against the last turn, so that in vibrating the convolutions approach or recede from one another. A very slight motion of the diaphragm is sufficient to cause the first few coils to come together; and in general the number of coils that thus touch each other is dependant upon the amplitude of the diaphragm's motion. The wire is included in the primary circuit of an induction coil, so that the resistance of the circuit fluctuates as the diaphragm vibrates."

It is difficult to see any great difference between the telephone thus described in 1879 and Mr. Cuttriss's new instrument. The composition of the spiral is, indeed, not indicated; but at the date mentioned it was already well known that carbon was the best material for all microphonic purposes.—Yours, &c.,

A. A. C. SWINTON.

66, Victoria-street, London, S.W., January 11, 1892.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Offices not later than first post Thursday morning.*]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS INVITED.—The Durban (Natal) Town Council is prepared to grant concessionary rights to an undertaker for the establishment of electrical conductors for the supply of electricity to the town of Durban. Some particulars will be found in our advertisement columns; and printed conditions, with plans of the town, may be obtained on application to Mr. W. H. Radford, C.E., consulting and representative engineer to the Durban Corporation, Angel-row, Nottingham, England. Tenders must reach the Town Clerk, Durban, Natal, on or before April 30, 1892.

SALE BY TENDER.—We have received from Messrs. Wheatley Kirk, Price, and Goulty, the schedule and plans of the pumping engines and boilers which they are instructed by the proprietors of the East London Waterworks Company to sell by tender. The engines may be seen at work on any week-day by arrangement with the auctioneers. The engines and boilers for disposal are of the "Hercules," "Cornish," "Ajax," and "Wicksteed" types, and are erected upon the late premises of the Waterworks Company at Old Ford-road, Bow, London, E.

ALMANACKS, &c.—We have received from the Bell's Asbestos Company a neatly-printed illustrated sheet almanack.

——— We have received from the Anglo-American Telegraph Company a blotting pad and calendar for 1892, upon which is printed a section of a map showing the cables owned by the Company.

ROPER'S ELECTRICAL ENGINEERING COMPANY (LIMITED).—This firm sends us a copy of their newly-issued catalogue.

THE PAST YEAR'S WORK.—Messrs. J. D. F. Andrews and Co. report that their system of concentric wiring has come into general favour during the past year. Many important installations have been carried out both in London and the country, including a large installation at the Waterloo Grain Warehouses and the Park Hill Petroleum Stores. Three contracts have been concluded with the Mersey Dock Board. It will be in the recollection of our readers that a number of the leading insurance companies have had this system under their consideration during the past year, and have included clauses in their rules dealing with its introduction. Messrs. Andrews and Co. have also during the part year executed some large ventilating contracts.

——— Messrs. W. T. Goolden and Co. report favourably of the past year's work, all branches of their extensive business having experienced considerable activity. The firm have executed large contracts for dynamos, instruments, and accessories for central station work, and for private house and other installation work by steam and water power. The electric mining machinery department has been exceptionally active, and the contracts for the year include plants for pumping, holing, rock drilling and coal cutting. The supply of motors for workshops, launches, &c., has also been considerable during the past year. The prospects for the present year are reported fairly good.

——— The Telegraph Manufacturing Company have again to report progress and full work in all their departments. During the past year a largely-increased sale has taken place in their well-known manufactures of vulcanised and other cables for electric lighting. In telephone switchboards, railway telegraph, and other instruments, a heavy year's work has been done; their new Liverpool instrument workshop having been kept fully going. Nearly a quarter of a million Leclanché batteries have been made and sold during the past twelve months, and the demand for insulators and line stores has been very large. This is no doubt partly due to the expiry of the telephone patents, but at the same time is also largely due to the promptness with which this Company execute the large orders entrusted to them. It will be remembered that about eight years back the Company commenced the manufacture of gutta-percha wire and cable, and large orders have been received during the past year for these manufactures. For 1892 the Company starts with the brightest prospects for a busy year's work.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

December 10, 1891.

21,728. A. G. WATERHOUSE. London. Improvements in electric arc lamps.

December 12, 1891.

21,766. S. SCHUCKERT and A. WACKER. London. Improvements in apparatus for measuring the expenditure of electrical energy.

21,778. A. PETERS, jun. London. Electrical safety signalling apparatus for railway trains, also applicable for applying the brakes.

21,783. F. J. BEAUMONT. London. A novel combination of metallic wires to dispense with the use of electromagnet or solenoid as such in arc lamps.

December 14, 1891.

27,816. C. SCHUBEL. London. Improvements in incandescent lamps.

21,849. B. S. PATERSON and J. B. FURNEAUX. London. Improvements in armatures for dynamo-electric machines.

21,854. A. J. BOULT. London. Improvements in or relating to the insulation of electrical conductors. (E. L. Montgolfier and C. V. Montgolfier, France.)

December 15, 1891.

21,870. H. H. LAKE. London. Improvements in voltaic cells or batteries. (E. A. Clark, United States.)

21,923. F. H. BERRY. London. An improved electrical apparatus for driving clockwork.

21,941. W. GUMBLEY. London. Improvements in electric motor mechanism for vehicles.

21,963. M. W. DEWEY. London. Improvements in converter systems for electric railways.

December 16, 1891.

21,987. G. R. STOKES. Hanley. Improvements in suspending telegraph and telephone wires and attachments on open-air supports of same and telephonic switch-boards.

22,025. J. SMALLWOOD. London. Improvements in fittings for electric lights.

22,027. V. SILBERBERG. London. Improvements in gallery holders or supports for the globes or shades for electric lights and gas lamps, also applicable to holders for incandescent lamps.

22,030. C. HOEPFNER. London. Improvements in the electrolytic treatment of copper and silver ores.

22,037. H. H. LAKE. London. Improvements in printing telegraph receiving instruments. (J. E. Wright, United States.)

December 17, 1891.

22,080. J. GRUBB and W. H. STURGE. Birmingham. Improvements in roses for ceilings and wall connectors for electrical purposes.

22,109. B. J. B. MILLS. London. Improvements in systems of electrical distribution, especially adapted for supplying electric motors. (H. W. Leonard, United States.)

22,120. A. C. BOOTH and W. P. WARD. London. Improvements in telegraph repeaters.

22,122. M. HOOPES. London. An improved electric switch.

22,126. A. E. PORTER. London. An improvement in secondary batteries.

December 18, 1891.

22,145. W. P. THOMPSON. Liverpool. Improved jar or cell for galvanic batteries. (O. Hirsch, Germany.)

22,171. F. MORIN. London. Improvements in electric accumulators or secondary batteries.

22,181. L. H. ROGERS. London. Improvements in packets or pads for electric cells.

22,184. A. RETTIG. London. Improvements in or relating to telephones and microphones.

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December 19, 1891.

22,255. A. A. C. SWINTON. London. Improvements in electric telephone transmitters.

22,265. J. STEPHEN and C. DAVIS. London. Improvements relating to simultaneous telephony and telegraphy.

December 21, 1891.

22,284. H. EDMUNDS. London. An improved device for suspending electric cables or conductors.

22,304. S. P. THOMPSON. London. Improvements in means of electric transmission for telegraphic, telephonic, and other purposes.

SPECIFICATIONS PUBLISHED.

1890.

19,740. HIGGINS. Column printing telegraph receivers. (Price 11d.).
19,811. WYNNE. Propelling vessels by electricity. (Price 8d.)
20,175. FRAGER. Electric meters. (Price 8d.)

1891.

105. HASELWANDER. Electric conductors. (Price 8d.)
184. CROMPTON. Dynamo machines. (Price 8d.)
185. CROMPTON. Dynamo machines. (Price 8d.)
284. MAYER. Telephone transmitter. (Price 6d.)
899. EAGAR and MILBURN. Electric cells. (Price 4d.)
1,176. NEWTON and HAWKINS. Dynamo electric machines, &c. (Price 8d.)
1,318. CUTLER. Electric distribution. (Price 11d.)
1,779. HARTNELL. Electro-motors, &c. (Price 8d.)
2,067. BAUR and DRESELHORST. Electrical transformers. (Price 4d.)
3,262. GIMINGHAM. Electrical glow lamps. (Price 6d.)
3,373. WEBB and CRISP. Medical batteries. (Price 8d.)
3,664. BINSWANGER. Electrical switches. (Price 8d.)
14,912. MARCUS. Telephone mouthpiece. (Price 6d.)
17,107. RIDER. Electric arc lamps. (Price 6d.)
17,399. GILLILAND. Dynamo-electric machines. (Price 8d.)
17,733. LINDERS. Electric drilling, &c., machines. (Price 6d.)
17,734. LINDERS. Electric switches. (Price 6d.)
18,431. WADDELL and Others. Secondary batteries. (Price 8d.)
18,522. THOMPSON (Coffin). Welding metals electrically. (Price 6d.)
18,641. KELLY. Dynamo-electric machines. (Price 6d.)
18,902. REDFERN. (Bergmann.) Electric conductors. (Price 6d.)
18,916. NUTTALL. Electric car trollies. (Price 6d.)

COMPANIES' MEETINGS & REPORTS.

Eastern Telegraph Company (Limited).

The thirty ninth half-yearly ordinary general meeting of this Company was held yesterday, at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. George Draper) having read the notice convening the meeting,

The CHAIRMAN, at the outset of his remarks, referred with the deepest regret to the death of the Duke of Clarence, and expressed his conviction that they would all cordially sympathise with the Royal Family in the great trouble which had fallen upon them. Probably on no other occasion had news passed so rapidly over this vast Empire as the news of the death of his Royal Highness. The Company in which those present were all so much interested had been the medium of conveying the sad information to almost every civilised portion of the world, which had thus been made acquainted with it almost within the same space of time as we had been in London. He was convinced that throughout the world the deepest sympathy would be expressed with the Queen and the Royal Family. Referring to the working of the Company in the half-year to September 30th last, he stated that their message receipts for that period had been £321,135, being an increase of £2,407 over those of the corresponding period of 1890. The dividends from their investments in other companies had been £33,399, or £56 less. Their gross revenue had been £354,939, or an increase of £2,066. They would remember that from July 1st a considerable reduction of rates came into operation on inter-European telegrams ; and he was glad to say that this reduction had now been nearly recouped, showing the considerable vitality which existed in their business. Included in their present accounts was the loss on five months' traffic occasioned by the reduction of the tariff to Australia. They had had about eight months' experience of this reduction, but when he met them next time he thought he would be able to make a very satisfactory announcement on the subject. He did not think it desirable to give any figures at that moment; but it must be satisfactory to the shareholders to know that in spite of the important reductions in the tariff between European countries and with Australia, increased traffic with other countries where they had not been obliged to reduce their tariff – notably with South America—had enabled them, not only to cover the loss resulting from the reductions, but to show a small increase of revenue. The total expenses for the half-year had been £97,130, or £5,407 in excess of those of the corresponding period of the previous year. Included in this half-year's figures, however, was the item for "special repairs to buildings at Alexandria and Port Said, £2,450;" and the amount carried to the "maintenance ships' reserve fund" was £4,000, against only £2,500 in the corresponding period of the previous year. Several of the other items showed an increase, while in others there was a decrease. The general expenses in London had been £9,412, or £910 more. The working expenses at stations had amounted to £73,097, showing an increase of £4,662. The additional expenditure under the heading of salaries, wages, rent, &c., was incurred last year, the necessary increase in the number and additional pay and allowance granted to some of the foreign staff being the cause. The use of patents had cost them £755, against £1,416 in the September half of 1890. The reduction now shown would be permanent, some of the patents for which they had been paying royalties for several years having expired. The expenses attending repairs and renewals of cables had amounted to £47,048, showing an increase of £15,570. In the corresponding period of 1890 the amount chargeable for repairs for cables was exceptionally light, owing to the large credits derived from other companies for the hire of the Eastern Company's ships for cable repairing purposes. They had laid in 129 knots of new cable, the cost of which was included in the half-year's figures. The result, therefore, of this half-year's working was that, although they had a small increase in their gross revenue, they carried forward £57,509, against £78,195 in the corresponding period of 1890, or a decrease of £20,686. It must, however, be remembered that the September half of 1890 was an exceptionally favourable one as regarded ships' expenditure. He desired to call their attention to the important fact that, in spite of the large additions which they had made to their cable system during the last six years, the capital expenditure under this head had remained since 1885 at practically the same figure, notwithstanding that they had laid over 7,000 miles of new cable during that period. This half-year they had applied from the reserve fund the sum of £105,110 in reduction of capital expenditure, and the total amount charged against reserve and revenue accounts to September last was £1,101,463. The balance remaining in their general and other reserve funds was £508,509. He thought they would consider this a very satisfactory position to be in. About eleven years ago the shareholders were good enough to sanction the establishment of a staff endowment assurance fund. A few months ago, when he was addressing the Eastern Extension Company he drew the attention of the shareholders to an amended system which the Directors desired to introduce, and which at the present time was in the hands of the actuaries. Telegraphing was a very peculiar business. Probably the young men they employed were, so far as their fingers were concerned, more expert and cleverer than when they attained to double their age. If they were to get good servants around them they must hold out the prospect of some benefit for their enjoyment at the end of a long and arduous life. They thought that by encouraging thrift and economy and wise forethought on the part of their *employés*, they could attain the object in view by adding, on the part of the Company, to the sum created by the *employés*, so as to enable the latter to retire with a competency after attaining the age of fifty or sixty, as might be determined upon. The shareholders must bear in mind that their business was not an ordinary one, but one which necessitated great confidence being reposed in their servants ; and it was necessary for them to have around them a class of men rather above the average—men in whom confidence could be placed, well educated well connected, and men, in short, who would have some respect for their names and the position held by them. The shareholders must bear in mind that a great deal of their work was conducted in distant countries, in tropical climates, and not in very pleasant places. Living in these places did not tend very much to health, but still the Company always found men ready and willing to serve them; but they felt that it was very desirable to be just and generous to their *employés*, and to let them feel that the Company were in touch with them. As he had said, he would not go into the details of the scheme on that occasion, the matter being before actuaries, but he was very glad to witness the signs of approval which the shareholders had given to his remarks relative to what was intended. As he had said before, telegraphing became a greater necessity every day, and as the world grew, so must the demand for telegraphy increase ; and their arrangements and appliances placed them at the head of everything connected with telegraphy. They had some cables still to duplicate, and this work would be carried out in due course. They were, however, most desirous, above all things, not to overburden their capital. Taking into consideration the reduced value of money he thought it was very gratifying that they were still able to maintain their dividend. He thought they might be satisfied that the investment they had made in the Company was a good and sound one, and it was regarded in that light by the commercial world ; for, in spite of the great depression which had prevailed for so long, the shares of the Eastern and of the Eastern Extension Companies stood rather higher to-day than at any period of their existence ; while their Four per Cent. Debentures were quoted at 108 to 109. He concluded by moving "That the report and accounts of the Directors to September 30, 1891, submitted to this meeting be and the same are hereby received and adopted."

The VICE-CHAIRMAN (the Most Hon. the Marquis of Tweeddale) seconded the motion.

A brief discussion followed, in which Mr. JOHN NEWTON, Mr. WEIR, Dr. WALLER, and Mr. WHISH took part.

The CHAIRMAN, in reply, stated that in the pension scheme to which he had alluded the shareholders might rely that the old and faithful servants of the Company would certainly not be forgotten. He had been asked whether their cables were in working order ; and he might state that they were in a condition above the average. They were rarely without a broken cable, but having adopted the system of duplicate cables wherever they had been able to do so, the public knew very little about breaks when they occurred. He might state that they had a very important break the other day in the South African cable, which, though another Company's, was practically owned by this Company. Had they not had their ships in order to attend to this break at once, the delay in

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effecting the repair would have been considerable. It was a remarkable fact that this cable was broken and repaired within five days, whereas if the matter had not been under their own control the repair would probably have taken two months. They not only repaired their own cables but some for other people besides. They never allowed their ships to lie idle if they could help it. During the present half-year they earned outside their own Company by their ships £15,000 ; and in the corresponding half-year of 1890 they earned in a similar way £22,000. He then put the resolution, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by the MANAGING DIRECTOR (Sir James Anderson). Sir A. J. Leppoc Cappel, K.C.I.E., was re-elected a Director ; as was also Lord Sackville A. Cecil, on the motion of the CHAIRMAN, seconded by Mr. J. D. PENDER.

The auditors (Mr. Henry Dever and Messrs. Welton, Jones and Co.) were afterwards re-elected.

Mr. NEWTON then proposed, and Dr. WALLER seconded a vote of thanks to the Chairman and Directors, both speakers cordially testifying to the services rendered by these gentlemen.

The CHAIRMAN, in reply, observed that there was no encouragement so great and so stimulating as that of the approval, six months after six months, of the body of their shareholders in the work done for them by their Directors. He was going away for a couple of months, and he intended to visit some of the Company's stations in the Levant and other places. He would thus be brought into contact again with their *employés* abroad ; and the shareholders would be astonished to see how extremely thankful their servants were on the occasion of such visits. He was convinced that the more they could keep in touch with their people the better would they get their work done.

The proceedings then terminated.

(A full report of this meeting will appear in our next issue.)

Edinburgh Electric Supply Corporation (Limited.)

The second annual general meeting of the shareholders of this Corporation was recently held in Edinburgh Mr. Walter Berry, of Glenstriven, chairman, presiding.

The Directors' report made reference to the negotiations entered into with the Town Council, setting forth the position of the Company and the advantages that would result to the city were an arrangement arrived at whereby the lighting of the compulsory area comprised in the Provisional Order should be undertaken by it. The subject, the report continued, must shortly be considered by the Councillors, as they obtained the Royal assent to their Provisional Order in the beginning of last July, from which date they had only three years to complete this work within the compulsory area. Meantime, the Directors had collected a large mass of information and statistics connected with similar works, finished and in progress, throughout the United Kingdom and elsewhere, which would enable them to tender for the electric lighting of the city should the Town Council decide on delegating their powers to the Company. In the meantime the shareholders had incurred no liability with regard to the expenses, nor would they do so unless the desired contract was obtained from the Council, when the shares would be issued to the public, and the business of the Corporation be at once proceeded with.

The CHAIRMAN, in moving the adoption of the report, said he had to express the regret the Directors felt in being still unable to intimate any progress towards the definite fulfilment of the object for which the Company was formed ; but no one was to blame for that. Without being too pressing, the Directors had not failed to urge their claims on the Town Council, and he could not doubt that these would be favourably considered when the Council was in a position to come to a decision. They must, of course, recognise that their representatives in the Council might decide that in the public interest it would be preferable for them to undertake the work themselves, and he had no doubt that, should they so decide, their decision would be arrived at on sufficient grounds. In that case the existence of their Corporation would terminate, and the preliminary subscriptions of the shareholders would be returned in full. As they were aware, the reasons why this Company was originally formed were—first, that it was deemed that there was sufficient business capacity in Edinburgh to carry out the electric lighting of our city, and that there was sufficient public spirit to form a local Company for that object ; secondly, that they objected very strongly to be tied to any one system. They knew that the Company against which they appeared as competitors was limited to its own special method, against which he had not one word to say. It might still prove the best, but they thought it well worth the trouble involved to attempt to keep our city free to adopt the best obtainable. Therefore, if the city entrusted the electric lighting of Edinburgh to their Company they should do their best to keep in the front rank, both scientifically and practically. They were naturally anxious to have the business ; but the shareholders might rest assured that although their Directors would not be greedy for profit, they would not undertake any contract which did not, in their view, leave a good margin for interest and risk.

Mr. G. BARCLAY having seconded the motion for the adoption of the report, it was adopted unanimously ; and, on the motion of Sir THOMAS CLARK, a vote of thanks was passed to the Chairman.

British Electric Light Company (Limited).

The ordinary annual general meeting of the shareholders of this Company was held on December 30, 1891, at Westminster. The proceedings were merely formal, and no business was done beyond the adoption of the Directors' report and accounts, and the re-election of Mr. W. F. Williams, the retiring Director, and of the auditors.

The following is the Directors' report read and adopted at the meeting :—

"The Directors beg to submit to the shareholders the accounts and balance sheet, showing the working of the Company for the past year, ending October 31st.

"In consequence of the Woodhouse and Rawson Manufacturing and the Woodhouse and Rawson Supply Company having gone into liquidation, the business carried on under the agreements with those Companies ceased, and the terms of a settlement of all outstanding claims have been arrived at, and are now waiting completion. A new arrangement was then entered into with the Ateliers Hoster de St. Nicolas (Limited), and with the Electric Stores (Limited) for the manufacture and sale of lamps, Mr. Albert Hoster acting for both companies. Under this arrangement the benefit to this Company from the sale of lamps will extend for ten years beyond the term of Messrs. Edison's patents. An agreement has also been come to by which this Company will, during the term of Messrs. Edison's patents, not manufacture any incandescent lamps, this Company receiving £2,000 compensation. Included in this arrangement is the settling up of all and every outstanding differences between the Woodhouse and Rawson Companies, Edison Swan Company, and this Company, leaving it in future a free hand to carry on its own business without the constant risks and expenses of legal proceedings, which have been so frequently threatened and incurred during the last two years. The Company will immediately benefit by this arrangement, and steps have already been taken to start other business.

"A reference to the account will show a balance to the credit of profit and loss account of £1,286. 13s. 10d , which is inclusive of £427. 11s. 8d. brought forward after payment of dividend last year. This amount is in part made up of certain sums still outstanding in the claim against Messrs. Woodhouse and Rawson.

"Of the available balance the Directors propose to pay interest at the rate of 5 per cent. on the Ten per Cent. Preference Shares, and 3 per cent. on the Six per Cent. Preference Shares, which will require £648. 10s., leaving the balance to be carried forward.

"Mr. W. F. Williams, the Director retiring by rotation, and Messrs. James and Edwards, the retiring auditors, being eligible, offer themselves for re-election."

NEW COMPANIES, STATUTORY RETURNS, &c.

ELECTRIC FITTINGS, HIRING, AND MAINTENANCE COMPANY (LIMITED).—This Company was registered on January 6, 1892, with a capital of £200,500, divided into 40,000 ordinary shares of £5 each and 500 founders' shares of £1 each, by Messrs. Ashurst, Morris, Crisp, and Co., 17, Throgmorton-avenue, London, E.C. The objects are :—(A) to construct, lay down, establish, fix and maintain all cables, wires, lines, accumulators, lamps, works, and fittings of every description for the generation, distribution, supply, accumulation, and employment of electricity. (B) to carry on the business of electricians, generators, and suppliers of electricity, mechanical engineers, and manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, distribution, supply, distribution, and employment of electricity. (C) to carry on all or any of the businesses of iron, brass, metal, and other founders and fitters and metal workers, and for other purposes. The first subscribers are :—

	Shares.
Sir A. Armstrong, K.C.B., The Albany, Piccadilly	1
Colonel B. H. Martindale, C.B., Bickley, Kent	1
William Crookes, F.R.S., 7, Kensington Park Gardens, W.	1
F. R. Reeves, Little Heath, Potters Bar, electrical engineer	1
Arthur Palliser, jun., 21, Lime-street, E.C., merchant	1
Harry Fleet, 4, Heyworth-road, Clapton, London, accountant	1
Joseph William Tucker, 14, Addiscombe-grove, Croydon	1

The number of the Directors is not to be less than three nor more than seven. The first Directors shall be the persons who shall be nominated by a majority of the subscribers to the Memorandum of Association. Qualification, the holding of shares of the Company of the nominal value of £200.

INVENTIONS CONTRACT SYNDICATE (LIMITED).—This Company was registered on January 7, 1892, with a capital of £5,000, in £1 shares, by Emanuel, Round, and Nathan, 27, Walbrook, London, E.C. The objects are "to establish, acquire, and carry on all or any of the businesses of manufacturers, vendors, and purchasers of and dealers in all inventions, patents, and processes incidental to the business of engineers, and also manufacturers, producers, vendors, and purchasers of and dealers in all mechanical and engineering machines, inventions, contrivances, and processes, pneumatic, hydraulic, chemical, and electrical apparatus, machines, and inventions, and metallurgical processes of any nature and for any purpose whatever."

MEIN'S ENGINE COMPANY (LIMITED).—This Company was registered on January 5, 1892, with a capital of £3,500, in £1 shares, by Le Brasseur and Oakley, 12, New Court, Lincoln's Inn. The objects are to work tramways, omnibus, railway, subway, and other lines, by mechanical and other power, to generate and sell power for locomotives, fixed engines, or any other purposes, and to form centres for the accumulation and distribution thereof. The first subscriber is Mr. Edward Mein, Station-street, Stratford, London, E., engineer.

METROPOLITAN LIGHT COMPANY (LIMITED).—This Company was registered on January 7, 1892, with a capital of £5,000, in £1 shares, by John Hands, 15, Old Jewry-chambers, London, E.C. The objects are : To

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purchase or otherwise acquire the business now carried on by Daniel C. Defries at 43 and 44, Holborn-viaduct, London, under the name of "The Metropolitan Light Company;" to carry on the business of manufacturing or mechanical engineers, gas engineers, electrical engineers, machinists, ironmongers, &c., and to provide and supply gas or electricity, or electrical currents or force for lighting and heating purposes. Mr. Daniel C. Defries is the Managing Director until he resigns the office, or dies, or ceases to hold at least £1,000 in shares.

OAKDEN AND SHARPE (LIMITED).—This Company was registered on January 9, 1892, with a capital of £20,000, divided into 15,000 ordinary shares of £1 each and 500 preference shares of £10 each, by Waterlow and Sons (Limited), London Wall, E.C. The objects are to acquire and carry on the business (amongst others) of wholesale and general furnishing ironmongers, steam, electrical, and ventilating engineers, electricians, and art metal workers, carried on by Messrs. Oakden and Sharpe, at Great Grimsby, Lincolnshire.

BRITISH ELECTRO-CHEMICAL AGENCY (LIMITED).—The statutory return of the above-named Company made up to the 24th December, 1891, was filed on the 6th January, 1892. The Company was registered on the 11th August, 1891, with a capital of £75,000, divided into 5,000 ordinary, and 2,500 "vendors'" shares of £10 each, to acquite certain patents from the Electric Construction Corporation (Limited), and to work the same. The directorate comprised Mr. Joseph Ebbsmith, Mr. John B. Verity, and Mr. James Balfour. At the time of making-up, 4,099 shares were taken up, and upon 1,599 ordinary shares £1 per share had been called, resulting in the payment of £839. 10s., leaving £759. 10s. in arrears. Registered office: Worcester House, Walbrook, London, E.C.

CENTRAL ELECTRICAL COMPANY (LIMITED).—The first registered office of the above-named Company (full particulars of which were published in *The Electrician* of last week) is situate at 47 and 48, Broad-street-avenue, London, E.C. (filed on January 5, 1891).

CHATHAM, ROCHESTER, AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above-named Company, made up to December 23, 1891, was filed on January 4, 1892. The Company was registered on July 15, 1887, with a capital of £10,000, in £5 shares. By special resolution, passed November 21, 1888, and confirmed December 13, 1888, the capital was raised to £50,000 by the addition of 8,000 shares of £5 each. 2,027 shares have been taken up, upon 2,000 of which the full amount has been called, and upon the remaining 27 £1 per share has been called, resulting in the payment of £10,025, and leaving £2 unpaid. Offices and works: Victualling Office Wharf, Rochester.

CRYSTAL PALACE DISTRICT ELECTRIC SUPPLY COMPANY (LIMITED).—The approval of the Board of Trade to the change of the above Company's name from the Electric Installation and Maintenance Company (Limited) to its present title, was granted on January 1, 1892, and the official certificate granted on January 4, 1892. Registered office: 4, Great Winchester-street, London, E.C.

ELECTRICITY SUPPLY CORPORATION (LIMITED).—At an extraordinary general meeting of the members of the said Company, duly convened and held at No 2, Craig's-court, Charing-cross, in the County of London, on December 7, 1891, the following special resolution was duly passed; and at a subsequent extraordinary general meeting of the said Company, also duly convened and held at the same place on December 22, 1891, was duly confirmed:—"Resolved unanimously that the capital of the Corporation be increased from £100,000 to £150,000, and that such further sum of £50,000 consist of 5,000 ordinary shares of £10 each, to rank equally with the ordinary shares of the Corporation in all respects." The annual return of the above-named Corporation, made up to January 5, 1892, was filed on the same day with the above. The Company was registered on June 12, 1889, with a capital of £100,000, divided into 9,900 ordinary and 100 founders' shares of £10 each, to apply for, obtain, undertake, and carry out a Provisional Order for the supply of electric light and power within the parish of St. Martin's-in-the-Fields, in the county of Middlesex, and also generally any contracts, Acts, Provisional Orders, licences, decrees, and concessions for or in relation to the supply of electricity in Great Britain and elsewhere. At the time of making-up, 359 ordinary shares had been taken up, the full amount called, and all calls paid. Registered office: 12, Maiden-lane, Covent-garden, London, W.C.

GENERAL ELECTRIC POWER AND TRACTION COMPANY (LIMITED).—The first annual return of the above-named Company, made up to January 1, 1892, was filed on the 9th following. The Company was registered on May 22, 1890, with a capital of £350,000, divided into 10,000 preference and 25,000 ordinary shares of £10 each, to unite the businesses of the Electric Traction Company (Limited) and Moritz, Immisch, and Company. At the time of making-up, all the preference and 23,592 of the ordinary shares had been taken up, and 21,734 ordinary shares were issued and considered as fully paid. Upon the preference shares £6 per share has been called, and upon the remaining 1858 ordinary shares the full amount has been called. The total amount of calls received, including payments on application and allotment, is £59,085 on the preference shares and £17,950 on the ordinary shares, leaving £915 due on the preference and £630 on the ordinary shares. Registered office: New Broad Street House, London, E.C.

NATIONAL COMPANY FOR THE DISTRIBUTION OF ELECTRICITY BY SECONDARY GENERATORS (LIMITED).—The annual return of this Company made up to December 30, 1891, was filed on January 6, 1892. The Company was registered on May 11, 1883, with a capital of £500,000, in £10 shares, which shares are now divided into 3,000 preferred and 47,000 ordinary.. 2,669 preferred and 20,000 ordinary shares have been taken up, and upon 1,669 of the preference the full amount has been called and paid. The total amount of calls received, including payments on application and allotment and £1,000 paid on forfeited shares, equals £17 690. Total amount agreed to be considered as paid on 1,000 preferred and 20,000 ordinary shares is £210,000. Registered office: 18, Warwick-street, Regent-street, London, W.

NATIONAL ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to the 13th May, 1891, was filed on the 7th January, 1892. The Company was registered on the 28th October, 1889, with a capital of £100,000, divided into 19,900 ordinary and 100 founders' shares of £5 each. At the time of making-up, 98 founders' and 490 ordinary shares had been taken up, and upon the founders' shares £5 per share had been called, while upon the 490 ordinary shares £1 per share has been called, the whole resulting in the payment of £2,875, leaving £65 unpaid. Registered office: Victoria-buildings, Preston.

NEW CADOGAN AND BELGRAVE ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 1, 1892, was filed on January 7th. The Company was registered on June 30, 1890, with a capital of £1,000, in £10 shares, to acquire, take over, and carry on the business of the Cadogan Electric Light Company (Limited). At the time of making-up, seven shares had been taken up, upon which, however, nothing had been called or paid, the original subscribers being the only shareholders. No agreements for the taking over of any business, plant, contracts, &c., have as yet been filed. Registered office: 91, Manor-street, Chelsea, London, S.W.

OXFORD ELECTRIC COMPANY (LIMITED).—The statutory return of the above-named Company, made up to the 26th December, 1891, was filed on the 9th January, 1892. The Company was registered on the 24th of August, 1891, with a nominal capital of £100,000 in £5 shares, to carry on in the City of Oxford and its neighbourhood the business of electric lighting in all its branches, and to enter into and carry into effect an agreement about to be made with the Electric Construction Corporation (Limited). At the time of making up, 67 £5 shares had been taken up, £2. 10s. called on each, and £100 paid, leaving £67. 10s. in arrears. A note at the end of the return states that "In addition to the above shares 10,100 shares are appropriated for payment on completion of the works in progress, under contract August 13, 1891, made between this Company and the Electric Construction Corporation (Limited), Worcester House, Walbrook, E.C.—(Signed), GEORGE OFFOR, Manager and Secretary." Registered office: 4, Great Winchester-street, London, E.C.

ST. PAUL'S PRINTING AND PUBLISHING COMPANY (LIMITED).—The first registered office of the above Company (*see* last week's *Electrician*) is 22, Paternoster-row, London, E.C.

TELEGRAPH IMPROVEMENT COMPANY (LIMITED). — The annual return of the above-named Company, made up to December 29, 1891, was filed on January 7, 1892. The Company was registered on June 8, 1881, with a capital of £100.000 in £1 shares, to acquire and work letters patent dated February 12, 1875, No. 525, granted to George Allan and James Wallace Brown, for the invention of "Improvements in Electric Telegraphs," and letters patent, dated April 26, 1876, No. 1,757, also granted to G. Allan and J. W. Brown, for an invention of "Improvements in Electric Telegraphs." At the time of making up, 15,006 shares had been taken up, upon 6 of which the full amount had been called and paid, the remaining 15,000 having been issued as fully-paid. Registered office: 10, Austin-friars, London, E.C.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended January 10th amounted to £858, as against £748 for the corresponding period of 1891, an increase of £110.

ELECTRICAL FITTINGS, HIRING, AND MAINTENANCE COMPANY (LIMITED).—We have received a copy of the prospectus of this Company, which is formed with a capital of £200,500, in 40,000 ordinary shares of £5 each, and 500 founders' shares of £1 each, the whole of the latter having been subscribed for. The present issue is for £100,000, in 20,000 ordinary shares of £5 each, payable 10s. per share on application, £1 per share on allotment, and the balance in sums of £1 at intervals of not less than two months. The Directors are Sir Alexander Armstrong, K.C.B.; Colonel B. H. Martindale, C.B.; Prof. W. Crookes, F.R.S.; and Messrs. J. Browne-Martin and T. G. Fardell; and the secretary and offices (*pro tem.*) are Mr. W. F. L. Frith, 9, Austin Friars, London, E.C. The prospectus states that the Company is formed for the purpose of assisting intending consumers of the electric light in adapting the same to their establishments. The Company propose to facilitate the introduction of electric light and power by executing all the needful interior work of buildings, &c., and receiving payment for this work by instalments. The Company will be prepared to supply all kinds of lamps, electroliers, motors, &c., and for this purpose will establish show rooms, where samples of apparatus and fittings will be on view. The Company will issue a guarantee with all its work, and maintain the same free of cost for the sum agreed upon between the parties. Prospectuses and forms of application for shares can be obtained of the bankers of the Company, Messrs. Barclay, Ransom and Co.; of the solicitors, Messrs. Ashurst, Morris, Crisp and Co.; or at the offices of the Company.

GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).—At a meeting of the Directors, held on Tuesday, an interim dividend was declared of 3s. per share on the preference shares, less income-tax, and of 1s. 6d. on the ordinary shares, income-tax having already been deducted.

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HUMBOLDT ELECTRIC POWER AND MINING COMPANY (LIMITED).—A private meeting of the shareholders was held on Wednesday at the Great Eastern Hotel, London, E.C., to receive the liquidator's report and statement of accounts.

THE SIAM ELECTRIC LIGHTING COMPANY.—This Company has raised further capital by issuing the balance of its shares, and electric lighting at Bangkok has been resumed.

CRICKET.—A cricket match was played at Malta on December 31st last between the Eastern Exiles C.C. and sergeants of the Welsh Regiment, resulting in a win for the Club by 52 runs. Scores:

EXILES' CLUB.—Mr. A. E. Saunders, c Harman, b Dyne, 13; Mr. P. Kirton, not out, 60; Mr. J. W. Roffey, b Dyne, 1; Mr. E. Costen, c Clieve, b Dyne, 5; Mr. Smith (c.s. "Amber"), b Heeley, 0; Mr. H. Bean, b Heeley, 21; Mr. Pickett (c.s. "Amber"), b Heeley, 1; Mr. Robb, c Heeley, b Harman, 0; Mr. E. D. Baines, b Heeley, 0; Mr. W. M. Ladds, b Heeley, 0; Mr. F. Nosworthy, b Heeley, 1; exras, 7—total, 109.

WELSH REGIMENT.—Sergt. Dyne, l b w, b Saunders, 2; Sergt. Poole, c Baines, b Pickett, 9; Sergt. Lawler, c and b Roffey, 23; Sergt. Curnow, c Nosworthy, b Saunders, 0; Sergt. Clieve, c Nosworthy, b Saunders, 4; Sergt. Swaine, run out, 0; Sergt. Kyte, c and b Saunders, 0; Sergt. Acramon, c Bean, b Saunders, 0; Sergt. Graham, c and b Saunders, 0; Sergt. Gain (sub), b Saunders, 8; Sergt. Jenkins (sub), not out, 0; extras, 11—total, 57.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Jan. 6	Price Wednesday, Jan. 13.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Jan. 13. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,200,980	Stock	12/6	Anglo-American	50½ 51½	50⅝ 51½	5 1 11	Jan., Apr., July, Oct.	51⅛	50⅞
£2,849,510	Stock	25/0	Do. Preferred	88¾ 89½	89 90	5 13 7	" "	89½	88¾
£2,849,510	Stock	5/0	Do. Deferred	13¾ 14¼	13½ 13¾	..	" "	13⅝	13½
£250,000	100	4%	African Direct, Telegraph 4% Debentures ..... xd	98 101	98 101	3 19 2	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine ..... xd	10½ 11	10⅛ 11	7 2 3	Mar., June, Oct., Dec.	10⅝	10⅛
£68,200	£100	5%	Do. 5 per Cent. Bonds	102 105	102 105	4 15 3	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906) .. xd	103 107	103 107	4 13 5	June and December	..	..
£7,716,000	$100	7%	Commercial Cable Capital Stock ..... xd	151 153	150 155	4 10 4	April and October ..	154	152
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	10⅝	10½
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½ 3⅝	3½ 3⅝	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9½ 10⅛	9⅝ 10⅛	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10⅝ 11⅛	11 11⅛	6 1 9	Jan., Apr., July, Oct.	10 5/16	..
400,000	10	2/6	Eastern	14 14½	14⅛ 14⅝	4 10 5	" "	14⅝	14
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15 5/16	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.....	106 109	106 109	3 13 5	May and November	109½	..
£100,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	109⅝	108½
250,000	10	2/6	Eastern Extension	15⅛ 15⅜	15⅛ 15⅜	4 11 1	Jan., Apr., July, Oct.	15⅜	15 7/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107 110	107 110	3 12 9	February & August	108	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 .. xd	102 105	102 105	4 15 3	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb..1900 xd	101 104	101 104	4 16 2	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99 102	99 102	3 18 5	Febuary and August	100⅜	..
180,227	10	2/0	Globe Telegraph and Trust	9⅞ 10⅛	9⅝ 10	5 7 6	Jan., Apr., July, Oct.	10⅛	10
180,042	10	6%	Do. 6 per Cent. Preference	14¾ 15	14⅝ 15	4 0 0	" "	15	14⅝
150,000	10	5/0	Great Northern ..... xd	19 19½	19 19⅛	4 7 2	Jan., April, and July	19⅛	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41 43	41 43	5 16 3	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	107⅛	..
9,000	8	4/0	Reuter's	7¾ 8¼	7¾ 8¼	4 16 11	April and October..	..	..
3,881	£100 Cert.	£2	Submarine Cables Trust 6%	117 122	116 121	4 18 4	" "	..	..
15,609	10	3/0	West African Telegraph ..... xd	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	97 100	100 103	4 17 1	March & September	99⅛	99⅝
30,000	10	2/0	West Coast of America	3½ 4½	4 5	..	January and July ..	4½	..
£150,000	100	8%	Do. Debentures 8% 1902 ..... xd	97 101	99 103	7 15 4	June and December	100	..
88,321	10	1/0	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9 9½	9 9½	6 6 4	May and November	9½	9½
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7½ 8½	7⅝ 8½	7 1 2	" "	..	..
67,007	15	6/0	Western and Brazilian	10½ 10⅝	10 10⅛	7 2 10	" "	10⅝	10
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6½ 6⅝	6½ 6⅝	5 7 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4 4½	3⅞ 4¼	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	104 107	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	104 107	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£178,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance. ..	⅜ ½	⅜ ½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16 1/8	1/16 1/8	6 3 11	Yearly	..	..
666,984	5	2/6	National	4½ 4¾	4½ 4¾	6 13 4	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 12¾	12½ 12¾	4 14 1	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12 12½	12 12½	4 16 0	" "	12 5/16	12
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd) .. xd	105 108	105 108	4 3 4	January and July ..	106⅜	105½
58,000	5	1/0	United River Plate	1 2	1 2	..	" "	..	..
£146,870	Stock	5%	Do. 5 per Cent. Debenture Stock..... xd	80 90	80 90	5 11 1	" ..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£6 paid)	5½ 6	6 6½	..	—	6 7/16	6
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	4½ 5	.. ..	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5½ 6	.. ..	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 6	.. ..	..	January and July ..	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2⅜ 2⅞	2⅜ 2⅞	..	March	..	..
10,000	£5	3½%	Do. (fully paid)	4⅜ 5⅛	4⅜ 5⅛	..	March	..	..
111,000	5	..	London Electric Supply	1 1⅛	1⅛ 1⅜	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½ 10	9½ 10	..	..	9⅜	9⅛
6,318	10	..	Notting Hill Electric Lighting (fully paid)	6 7	5½ 6½	—	..	..	..
18,680	£5	3/6	St. James' and Pall Mall	8½ 9	8½ 9	—	..	8⅞	8⅛
7,900	£5	7%	Do. 7% Preference	7½ 7¾	7 7½	—	..	7⅞	7 5/16
42,853	5	..	Westminster Electric Supply (£6 paid)	6½ 6¾	6½ 7	..	..	6⅝	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/8	Brush Electrical Engineering	3½ 3⅝	3½ 3⅝	..	..	3½	..
69,996	2	6%	Do. 6 per Cent. Preference	2½ 2⅝	2½ 2⅝	5 1 1	..	2½	2⅜
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares .. xd	5½ 5⅝	5½ 6	5 16 8	January and July ..	5⅝	5½
17,139	5	17½	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction ..... xd	5⅞ 6⅛	6 6⅛	..	—	6 7/16	6⅛
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅞ 4⅛	3⅝ 3⅞	..	—	3⅝	2⅝
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works ..	20½ 21½	20½ 21½	4 15 3	February & August	21⅛	20 13/16
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 106	4 4 11	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	4 5	4 6	..	..	..	..
11,334	£10	8/0	Do. Preference	8¾ 9½	8½ 9½	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛ ⅜	⅛ ⅜	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	4 4½	4 4½	8 11 10	May and November	4⅛	4⅛
36,250	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July.....	43½	42½
150,000	100	5%	Do. 5 per Cent. Bonds, red 1894 ..... xd	100 103	100 103	4 17 1	January and July .	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)..	1⅞ 2	.. ..	5 15 9	..	..	—
—	£5	8%	Do. Preference (fully paid).....	3⅝ 3⅞	.. ..	10 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	—	—	..	..
50,000	£10	—	City and South London Railway	2⅛ 3⅛	2⅛ 3⅛	..	—	..	..

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THE ELECTRICIAN:

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NOTES.

The Memorial to the Board of Trade on the subject of overhead wires has received a very large number of signatures, thus showing, as Major Flood Page observes in his letter, which will be found elsewhere, that there was a general feeling of anxiety that all overhead wires would be disallowed. The letter, which was sent to Messrs. Crompton and Co. was certainly sufficient to warrant the steps which were taken to draw up a Memorial and to make preliminary arrangements for an influential deputation; but we hope that by the publication of the other letter of the Board of Trade in our issue of the 8th inst. we have saved the President of that Department from some trouble, by making such a deputation unnecessary. We take it that the letter addressed to Messrs. Crompton and Co. related specifically to the lighting of Chelmsford, though by omission to make this clear it seemed to lay down a general rule.

We are not aware that any publication has yet been made of the "cases" in which overhead wires shall be or shall not be employed. It is possible that the pushing of the Memorial and of the proposed deputation might elicit some explanation; but it seems much more discreet to await further action by the Board of Trade, and not to force any premature decision. It is very evident to all who have had dealings with the Electrical Department that there is every desire on the part of the few but well-intentioned officers to do the best they can both for individuals and for the industry; and it is not advisable to encourage so slender a staff to make hasty decisions on matters of considerable weight. If any hard and fast rule is made now, it will practically have to be made by one or two men who have their hands full of other Government business.

Although, as Major Flood Page points out, the statement "that they will be prepared to authorise the use of such wires in any case in which they are satisfied that the interest of the public require it" cannot be regarded as altogether a satisfactory position in which to leave the question, we are given to understand that the intention of the Board of Trade is simply to disallow overhead wires in towns, and to permit them in the country. The question will resolve itself eventually into a definition of "town" and "country;" and the knotty point is, that what is country to-day may be town to-morrow. The street lighting of Chelmsford is obviously a case of "town"; the road between Weybridge Station and the town is probably a case of "country."

There exists at present, we understand, a statutory definition of a "rural sanitary district." We know nothing of, and take no interest in, the matter, except that any district which is recognised by Act of Parliament as "rural," will in all probability be allowed to add overhead wires to its natural charms. Another and supplementary definition, "urban sanitary district," includes, we imagine the remainder of the British Isles, and with it unhappy Chelmsford. But the Public Health Act, we are informed, deals with this question, and if a definition is introduced, the present condition of uncertainty is then at an end.

The financial results of last year's working of the St. James' station, which are set forth at some length in another part of the present issue, are of the satisfactory character to be anticipated in the case of a central station so favourably situated and so judiciously managed. In return for a total capital outlay of £139,000, the shareholders are in a position to place some £10,000 or more in their pockets, with the additional comfort of knowing that the money has been genuinely earned, that there is a reserve of £15,000, and that a "redemption fund" has been founded, The current metered during 1891 brought in £31,000 in round figures, which, taking the B.T.U. at 7d., means that considerably more than a million units were sold. The expenses of generation and distribution came to £11,187, or about 2½d. per unit; if we include expenses of management, depreciation, &c., we have roughly to double this figure; so that each unit metered must have brought in a clear profit of about 2d.

We print this week an interesting contribution by Dr. Fleming to the subject of alternate-current curves. The curves, already published by Messrs. Ryan and Merritt, have been subjected by them to a most searching analysis. The whole article is of interest, but that portion of it which deals with the magnetic leakage of transformers is of special value. The theory of transformers has, during the last two or three years, been simplified, and, at the same time, rendered more accurate, by the disuse of coefficients of self and mutual induction to represent the magnetic action of the coils, and by the adoption, in preference, of Dr. Hopkinson's

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method, in which only the total number of lines of force passing through the magnetic circuit is considered. The new method has many advantages; and the recent articles of Mr. EVERSHED in these columns have shown how easily it lends itself to all calculations needed in the design of transformers. It is, however, defective, since it assumes that every line of force produced in the primary coil threads the secondary circuit. As is well known, magnetic leakage exists to a greater or less extent in all transformers, and to take account of it theoretically is a most difficult problem; indeed, this is the first time that this subject has been attacked in a satisfactory manner.

IN discussing the general character of the results obtained, it must, however, be remembered that the transformer has no influence on the nature of the voltage, EE_1, which is impressed on the primary coil. This, of course, depends merely on the dynamo. Also, as Mr. EVERSHED'S articles have clearly shown, the variation of the magnetism in the core, and therefore of the secondary current, is dependent merely upon the primary voltage; for in all good transformers the number of volts absorbed by the wire of the primary coil is negligibly small compared with the primary potential. It is, therefore, the nature of the primary current, when the secondary is open-circuited, which reveals the character of the transformer itself; and it is unfortunate that the results are complicated in the present instance, owing to the fact that the alternator used for supplying the current had an electromotive force EE_1, represented by two sine waves of different periods, and the amplitudes of which were quite comparable with each other. Had E_1 been a simple sine wave, the influence of the transformer on the primary current could have been distinguished much more clearly.

IN connection with the problem of detecting the various harmonic components of a wave of alternating current or voltage, it may be interesting to recall attention to a Paper of Profs. AYRTON and PERRY read before the Institution of Electrical Engineers on March 28, 1889. On that occasion two electric frequency meters were described, the action of each depending on the principle of resonance. In the first method the current to be analysed was sent through one of the coils of a dynamometer, an alternating current of known frequency being sent through the second. The period of the latter current was altered till an attraction was observed between the coils, and the frequency of each component of the current tested could in this way be found. The other method consisted of passing the current through a stretched wire placed at right angles to the lines of force in a magnetic field. The vibrations of the wire were rendered as large as possible by adjusting its tension or length, and the frequency of one of the components could then be calculated. We may be prejudiced in favour of graphical methods; but we greatly prefer the simple and unmistakable method of superposing a true sine curve on the actually observed curve, and setting off the differences, though the dynamometer and stretched wire methods may be useful where no means are at hand for plotting the curve to be analysed, and the latter, at all events, forms an admirable lecture experiment.

THE *hum* of transformers, alluded to by Dr. FLEMING, forms an interesting subject by itself. In so far as it is due to the reversals of magnetism in the core it is dependent, not on the transformer itself, but on the dynamo and the engine driving it; for the changes of magnetism in the core respond exactly to the electro-motive force of the mains. It may, however, be partially due to action between the currents in the coils and the magnetism in the iron; and in this case it may be expected to change as the load is altered.

A DIFFERENCE of opinion exists as to the importance of the error due to lag, when iron wire coils are used for absorbing the load of alternate-current dynamos. In some cases it amounts to only one or two per cent., but we thought it worth while to ask Prof. EWING for further information on the subject than was given in his recent report on the Parsons Steam Turbine. The result of our enquiries, as we intimated a fortnight ago, was to confirm our estimate of the matter; but Mr. PARKER informs us in a letter, which will be found in our correspondence columns, that his experience is very different. It is a common practice to use a big voltameter for such tests, but the steam and gases boil off in so irregular a manner that accurate readings are very difficult. Such a water resistance was used at Thames Ditton in connection with the experiments on Mordey dynamos, described in our leader on July 17th of last year; and in the same number (*The Electrician*, Vol. XXVII., p 289) we ventured to cast some suspicion on the voltameter method, in consequence of Prof. MENGARINI'S experiments on alternating current electrolysis. It is improbable that any error from lag due to polarisation can exceed two volts, but on a 100-volt circuit that is about the same error which might be expected to arise from the self-induction of iron wire coils.

THE article on "Vertically-lit Lighthouses," which we reproduce from the columns of *The National Observer*, gives some interesting details of the experiments carried out by Lieut. WELLS at the Naval Exhibition. Some correspondence was addressed to the Elder Brethren of the Trinity House by the Secretary of the Shipmasters' Society, in August last, and the experiments at Chelsea were, as far as we have heard, the only recent practical result of the movement; but some very striking trials of "sky flashing" were made in the course of the South Foreland experiments in 1885: three reports on them will be found in Part II. of the Blue Book on this subject. It should be remembered that it is useless to throw a beam of light into the depths of a clear sky; and that it is only when a general haze makes the beam visible as a luminous shaft, or when there are clouds which may be illuminated, that this method can be of any service. In a thick fog on June 25, 1885, the three lighthouses at the South Foreland were all invisible at 1,000 feet, and on many other occasions the lights were lost at 1,200 or 1,300 feet.

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These thick fogs lie low, and it is under such circumstances that a vertical beam may be seen by vessels outside the fog-bank. A vertical beam would often be visible from a distance when the main light was obscured; but to abolish the ordinary horizontal light altogether, whether in clear or foggy weather, would be very unwise. Since it is impossible to throw, in a haze, the main light to the horizon, Mr. BREBNER and others have designed a system of "dipping" the beam, so that the few square miles of sea immediately surrounding the light which can alone be served, may receive the whole volume of light. The vertical beam might well be used during fogs in conjunction with the syren or bell, and with the "dipping" light if the lighthouse be high enough to make it worth while.

THE subject of electrical radiation is a very attractive one, however problematical its future uses may be. It offers the hope that light may some day be produced without the expenditure of much energy in heat, and that telegraphy may be accomplished without wires. By using radiation, which, unlike light, can penetrate fog, it may be possible, as already suggested in these columns (*The Electrician*, Vol. XXVI, p. 685), to arrange a system of signalling available in foggy weather; and apparently solid walls are no more opaque to these rays than glass is to ordinary light. The able article of Mr. TROUTON, concluded in this issue, will therefore be read with interest; and the close resemblance between optical and electric waves will be fully acknowledged when even the phenomena of thin plates and of the reflection of polarized light are shown to be the same for both.

AS Mr. TROUTON points out, the difficulty in the way of the complete investigation of these radiations is due to the small quantity of energy possessed by them, as at present generated. They die out with great rapidity, and thus produce but slight effect at great distances. If a beam of these rays, radiating several horse-power, could be produced, results of much value would be speedily arrived at. Mr. TESLA'S dynamos produce currents of as great a frequency as 10,000 $\sim$, but this is probably the limit possible with a single dynamo. The ingenious device suggested by Mr. TROUTON deserves close attention, as it appears to point out a way of getting currents of much greater frequency.

IF an alternating current is sent round the laminated field magnets of an alternator whose armature is stationary, an alternating current is generated in the latter, just as if the field magnets revolved under the excitation of a steady current. The effect of revolving the armature, as well as exciting the field magnets with an alternating current, is thus the same as if the field magnets were revolved at one speed (under steady excitation) and the armature revolved independently at some other speed. In fact, the effect of the alternating current in the field magnets is to produce what electricians have lately become familiar with as a rotating field, the speed of rotation being determined by the frequency of the alternating current. The result of the double rotation is to produce an alternating current whose frequency corresponds with the sum or the difference of the speeds according as these are in opposite directions, or in the same direction. If the alternating current in the field corresponds with the rate of revolution of the armature, a current of double this frequency is produced in the latter, as Mr. TROUTON points out. But it appears to us that the method can be carried still further, for by passing this armature current into the field of a second alternator, and revolving its armature at the same rate, a current of the sum of these frequencies, *i.e.*, three times the frequency of the original current, can be obtained.

Lord Rayleigh.—The Queen has been pleased to approve the appointment of Lord Rayleigh to be Lord-Lieutenant and Custos Rotulorum of the county of Essex, in the room of Lord Carlingford, resigned.

Inverness.—The Inverness Police Commissioners last week agreed to ask the Caledonian Canal Commissioners to give the necessary supply of water from the canal, should the Commissioners resolve to introduce the electric light.

Islington.—At a recent meeting of the Islington Vestry, it was decided, after a vigorous discussion, to give a conditional consent to the application by Messrs. Sharp and Kent for a Provisional Order for lighting certain portions of the parish.

Whitehall Club.—A dinner of the electrical engineers who are members of the Whitehall Club is to be held on Friday, the 29th inst., at the Club; it is hoped that Mr. Tesla will be present, unless the postponement of his lecture from the 28th inst. to February 3rd delays his arrival in London.

Royal Society.—The following electrical Papers were down for reading yesterday before the Royal Society:—Major Cardew, "On a Differential Electrostatic Method of Measuring High Electrical Resistances." Prof. Schuster, F.R.S., and A. W. Crossley, "On the Electrolysis of Silver Nitrate in Vacuo."

Another Columbian Exhibition.—An Exhibition in commemoration of the discovery of America by Columbus is to be held at Genoa, in Italy, during the present year. The whole of the Exhibition building and grounds will be lighted by electricity, the contract for the installation having been given to Messrs. Schuckert and Co., of Nuremberg.

Electrical Bills in Parliament.—Among the Bills which have passed the Examiners on Standing Orders of the House of Commons, are those of the St. Pancras Vestry, the City and South London Railway, and the Hampstead, St. Pancras, and Charing Cross Railway. In respect to the proposed Waterloo and Royal Exchange Railway there was no appearance on behalf of the promoters, and the Bill was struck out of the list.

The Crystal Palace Exhibition and Railway Rates.—The London Chamber of Commerce recently approached the London, Brighton, and South Coast, and the London, Chatham, and Dover Railway Companies with a view of securing a reduced rate on exhibits intended for the Electrical Exhibition at the Crystal Palace. The Companies did not see their way, however, to grant reduced rates, but have now agreed to convey the *unsold* exhibits on the return journey, free of charge, to any station on either of these lines of railway, provided that the exhibits remain the property of the exhibitors.

Street Electric Lighting in St. Pancras.—The Electricity Committee of St. Pancras made some experiments in the early hours of Saturday morning by testing the arc-lights placed along the centre of Tottenham Court-road. Prof. Robinson and Mr. Alderman Gibb accompanied the committee; and after all the business houses were closed the electric light was, first of all, put on, and the street lamps put out; then the case was reversed; and the contrast is said to have exceeded the most sanguine expectations, the 12 electric lights giving

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considerably more light than the 85 ordinary street lamps. The experiments were regarded as very satisfactory.

The Metropolitan Telephone System.—A meeting of the General Telephone Committee appointed by the Council of the London Chamber of Commerce to inquire into and report upon the general position of telephony in London, met on December 18, 1891, and considered a list of complaints preferred against the National Telephone Company. Colonel Jackson and Mr. Sinclair gave what were deemed satisfactory explanations on behalf of the Company, and it was agreed to recommend the Council of the Chamber to press the Government to confer statutory powers, it being urged that only by this means can an efficient telephone service be secured throughout the Metropolis.

The Liverpool Overhead Railway.—The Directors of this railway recently paid a visit to Birmingham for the purpose of inspecting a carriage which has been constructed for them at the works of Brown, Marshall, and Co., Saltley. The pattern carriage is 45ft. long and 8ft. 6in. wide, runs on bogey wheels, and is arranged with a gangway from end to end. There are three compartments—one first-class for 16 passengers, and two third-class compartments for 20 each, with an end compartment for the driver. The weight of the carriage, including the motor, is 14 tons. The Liverpool line is about 6½ miles long, and there will be 13 stopping places, including the termini. It is intended to charge a universal fare of 2d., with 1d. extra for first-class. The carriage was approved, and 30 similar ones are to be constructed.

Old Students' Association.—We are asked to announce the fact that Mr. Reginald J. Jones has been obliged to resign (owing to pressure of professional work) the Hon. Secretaryship of the Old Students' Association, which he has held since the beginning of the session 1890-1. The Association has secured the services of Mr. E. B. Vignoles as Hon. Secretary and Hon. Treasurer, and Mr. A. E. Ruddock as Assistant Hon. Secretary. All correspondence and subscriptions should in future be sent to E. B. Vignoles, Hon. Secretary and Hon. Treasurer, O.S.A., 28, Lanhill-road, Elgin-avenue, W. The membership of the Association is steadily increasing: last session 62 members and associates were elected; while this session, up to December 31st, no less than 38 members and associates have been proposed for election.

The City Lighting.—As stated in our City Notes, the City of London Electric Lighting Company has issued the balance of its ordinary shares at 5s. per share premium, and, accompanying the circular published in reference to this issue, the Directors give an account of the progress made by the Company, in which they state that current is now being supplied from the two generating stations situate at Meredith Wharf, Bankside, and at Wool Quay, Lower Thames-street, E.C., and that the erection of additional generating plant is being proceeded with. Queen Victoria-street, Gracechurch-street, King William-street, and Cornhill are already lighted, and in a few weeks a number of the main thoroughfares of the City will also be lighted. The Mansion House was lighted from the Company's mains in December last. Since then the engineering staff has been continuously employed in connecting the premises of further customers. Signed applications for about 13,000 lamps have been already received, and are being added to at the rate of 1,500 a week.

The London County Council and Overhead Wires.—We have received a copy of some correspondence between the Secretary of the London Chamber of Commerce and the London County Council, in reference to the recently-issued overhead bye-laws. The Chamber of Commerce asks the County Council to furnish it with the reasons which led the Council to issue the regulations in question, and states that several members of the Electrical Trade Section affirm that it will be impossible to carry on their business if the regulations are strictly enforced, and that it is proposed to hold a meeting in order that representations may be made on the subject. The County Council replies that it advertised the regulations in *The Times*, and sent copies out for the information of all firms concerned. The Council further states that before making a formal application to the Board of Trade for confirmation of the bye-laws, it is prepared, as also is the Board of Trade, to consider any objections or observations which may be offered with regard to them by any persons interested. Any such representations should be sent to the Council and the Board of Trade some time before the end of the month.

Obituary.—We regret to record the death, at his residence at Gipsy Hill on the 16th inst., of Mr. W. Lewis Wells, at the age of fifty-six. Mr. Wells entered the service of the Electric and International Telegraph Company at an early age, and became head of the clearing house, retiring with a pension on the acquisition of the inland telegraphs by the Government. He joined Messrs. Glass, Elliot and Co., as accountant to the Malta and Alexandria Telegraph Company, in 1858, and was also accountant to the Telegraph to India Company during its short existence. In 1870 he entered the service, as traffic accountant, of the seven Associated Submarine Cable Companies, which had grown out of the Malta and Alexandria Company, and which were amalgamated into the Eastern and Eastern Extension Telegraph Companies; and in this capacity attended the International Telegraph Conferences at Rome, St. Petersburg, London, Berlin, and Paris. He was also secretary of the Submarine Cables Trust and a Fellow of the Statistical Society. For many years Mr. Wells suffered from chronic bronchitis, and finally succumbed to an acute attack of that disease. He was much respected, and his loss will be regretted by the telegraph world.

Association for the Improvement of Geometrical Teaching.—The eighteenth general meeting of the Association for the Improvement of Geometrical Teaching was held at University College on January 16th. The following were elected to serve on the council for the current year:—*President*: Rev. C. Taylor, D.D. *Vice-Presidents*: R. B. Hayward, M.A., F.R.S.; R. Levett, M.A.; Prof. G. M. Minchin, M.A.; and R. Tucker, M.A. *Treasurer*: Prof. A. Lodge, M.A. *Hon. Secs.*: E. M. Langley, M.A., and C. Pendlebury, M.A. *Other Members of Council*: Mrs. Bryant, D.Sc., F.C.P.; C. V. Coates, M.A.; R. F. Davis, M.A.; A. S. Eve, M.A; C. Heppel, M.A.; Prof. W. H. Hudson, M.A.; Rev. S. S. Milne, M.A.; Prof. W. N. Stocker, M.A. The following papers were read:—"On Approximate Calculations" (Prof. A. Lodge), "On Laguerre's Dictum concerning Direction" (Prof. R. W. Genese), "On the Geometrical Interpretation of Fallacy in Elimination" (Prof. R. W. Genese), "On the Use of Horner's Method in Schools" (Mr. E. M. Langley). An informal address on the Geometrical Treatment of Infinite Complex Series was given by Mr. R. B. Hayward.

The Chicago Exhibition.—The French Government is stated to have asked for some 154,000 square feet of space at the Chicago Exhibition. Of this amount, 110,000 square feet are required in the Hall of Manufactures, 11,000 feet in the Cattle Show, and 33,000 square feet in the Fine Arts Gallery. Neither the Electricity nor Machinery Hall is included in this demand, and more space will, therefore, probably be asked for.—The necessary machinery for furnishing power to the Exhibition is being secured practically free of cost, manufacturers of engines, pumps, &c., being ready to supply power gratuitously. Some 50 separate contracts are to be let for the electric lighting of the Exhibition buildings and grounds. In all there will be used, according to present plans, approximately 127,000 electric lamps, of which 7,000 will be arc, of 2,000 c.p. each, and 120,000 incandescent 16 c.p. lamps. To run the plant 22,000 H.P. will be required. By the awarding of separate contracts for the lighting of each of the buildings and of different sections of the grounds, all electric firms, whether large or small, will have an opportunity to participate and to show what they can do, and at the same time a variety in illumination will be effected. In the great Manufactures building alone there will be 33,000 lights. The plans prepared by the electrical experts call for ten times the capacity of all the plants used at the Paris Exhibition. The Directors will spend $1,000,000, and perhaps more, for these electric plants. Exhibitors will not be required to pay anything for light, except in cases where they call for more lamps than are furnished by the construction department. In that event they will be furnished with additional lamps at actual cost.

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THE HARMONIC ANALYSIS OF TRANSFORMER CURVES.*

BY DR. J. A. FLEMING, M.A.

1.—The Harmonic Analysis of Currents and Electromotive Force Curves.—The method by which the curves representing the instantaneous values of the current and E.M.F. in any alternating-current circuit are obtained has been before explained (see *The Electrician*, Vol. 24, p. 239, 1890). It has also been shown ("Alternate Current Transformer," Vol. I., chap. III. § 3) how any single valued function of this form—that is, any non-intersecting and single-ordinate curve—can be resolved into a series of simple sine curves. That is to say, any such curve, however irregular, can be built up by adding together the ordinates of a series of simple sine curves

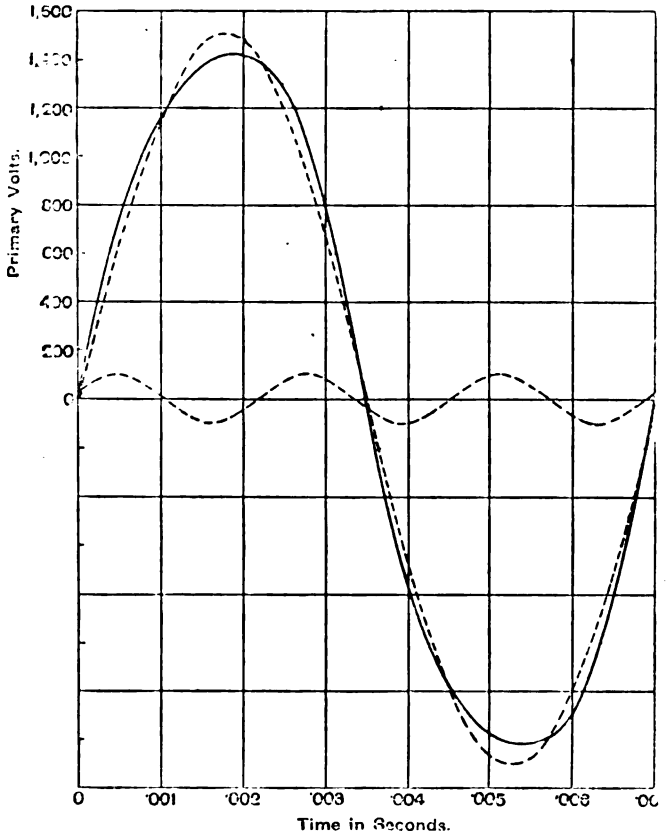


Fig. 1.—Harmonic Analysis of the Curve of Primary Electromotive Force of 10-Light Westinghouse Transformer. Dotted Curves represent the Harmonic Components.

whose wave-lengths successively decrease. In their investigations on transformers, Messrs. Ryan and Merritt obtained a large series of such transformer curves, some of which they have thus analysed and resolved into their harmonic constituents. The results of this work are shown in the appended diagrams.

Whatever may be its form, the equation of the curve can in every case be expressed in accordance with Fourier's Theorem by a series of sine and cosine terms, and we can write the instantaneous value x of the current or E.M.F. as expressed by the series

$$x = A_0 + A_1 \sin pt + A_2 \sin 2pt + \text{etc.} + B_1 \cos pt + B_2 \cos 2pt + \text{etc.}$$

In which the constants A_n and B_n are determined by the equations

$$A_n = \frac{2}{T}\int_0^T x \sin \frac{2\pi n t}{T} dt,$$

$$B_n = \frac{2}{T}\int_0^T n \cos \frac{2\pi n t}{T} dt.\dagger$$

Messrs. Ryan and Merritt determined the arithmetic values of these constants for all the observed curves. When the primary impressed E.M.F is thus analysed it is found that it can be expressed very nearly by four terms of the following Fourier series:—

$$E_1 = 1{,}500 \sin pt + 100 \sin 3pt - 42 \cos pt + 28 \cos 3pt.$$

Graphically it can be represented as in Fig. 1, where the dotted curves show the principal and secondary components of the original (firm line) curve. The primary E.M.F. is thus seen to be made up of a principal sine curve and a first harmonic of one-third the wave length. In the same way the secondary electromotive force was analysed and found to consist of a principal component and an harmonic of one-third the wave length (*see* Fig. 2). The expansion in harmonic terms for the secondary electromotive force being nearly

$$E_2 = -76{\cdot}2 \sin pt - 4{\cdot}8 \sin 3pt + 2{\cdot}7 \cos pt - 0{\cdot}1 \cos 3pt.$$

We shall not be far wrong in assuming that in all cases the curves of primary and secondary electromotive force are not very far removed from sine curves, and treating them accordingly. Doubt has been frequently thrown on this by some writers who have even ridiculed the assumption that the simple sine curve can express the form of the curve of electromotive force of any alternator; but strict investigation proves the assumption warrantable.

Moreover, an inspection of the indicator diagrams shows us that the phases of the primary and secondary electromotive forces are exactly opposite to one another, or differ by 180deg., when there is no secondary load on the transformer, but that when there is a secondary load the secondary electromotive force is a very little in advance of the primary in phase.

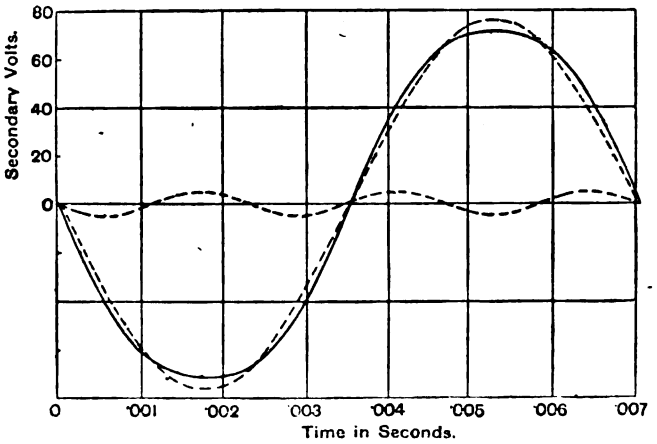
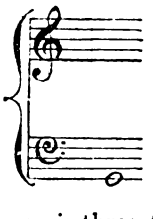


Fig. 2.—Harmonic Analysis of Curve of Secondary Electromotive Force of 10-Light Westinghouse Transformer.

It is quite different, however, with the primary current. We see by the eye, that when there is no secondary load the primary current curve is very far from being a simple sine curve. Messrs. Ryan and Merritt found that for the transformer they used the primary current curve could be analysed into three harmonic components (*see* Fig. 3), of which the wave lengths are respectively in the ratio, 1 : 3 : 5, and that it is expressible by the series,

$$i = 0{\cdot}129 \sin pt - 0{\cdot}148 \cos pt + {\cdot}011 \sin 3pt - {\cdot}047 \cos 3pt - {\cdot}016 \cos 5pt.$$

We might express the results of this harmonic analysis by musical notation. The middle C on pianoforte is a note having a frequency of 256. Hence the lower G on the base clef has a frequency of about 96; and, accordingly, the ordinary frequency at which transformer currents are worked being about 100, this is represented very nearly by the note

The note whose frequency is three times this is very nearly the lower F on the treble clef; and that whose frequency is

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† For the proof of this theorem the student is referred to Todhunter's 'Integral Calculus," Chap. XIII. Also Greenhill's "Integral Calculus," §183.

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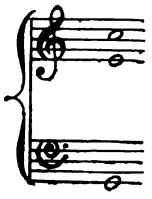
five times is the upper C on the treble clef. Hence the harmonic constituents of the primary current curve represented in Fig. 3 can be denoted very nearly by the musical chord

It would be interesting to see if a very acute musical ear could analyse the *hum* of transformer at work into its constituent simple notes.

If we inquire the cause of this distortion of the primary current the reply is that it is due to the hysteresis of the iron. If hysteresis were altogether absent the curve of primary current with open secondary would be a sine curve, lagging 90deg. behind the primary E.M.F. as represented by the dotted curve in Fig. 5. If eddy currents were set up in the core to any extent the effect of these would be to cause the primary current

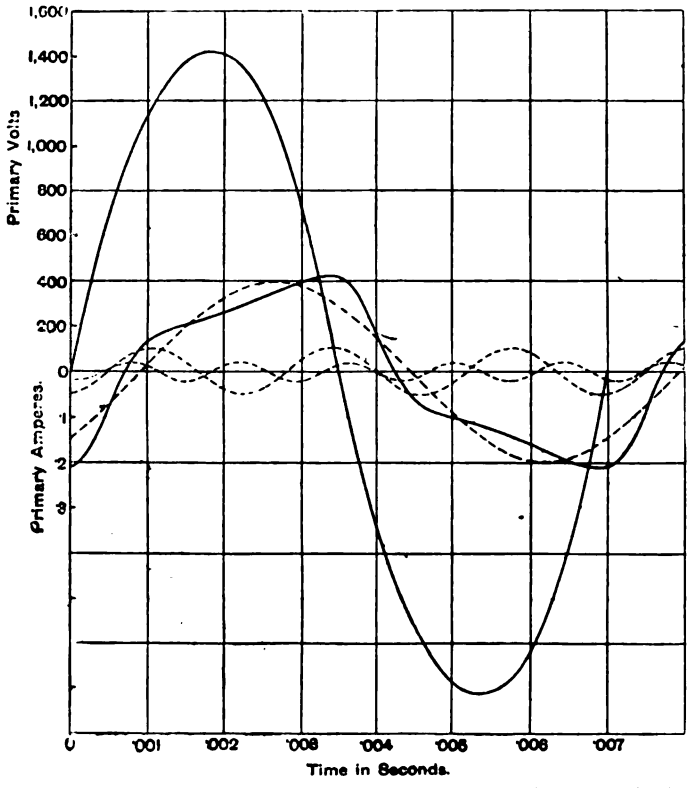


FIG. 3.—Harmonic Analysis of Curve of Primary Currents of the 10-Light Westinghouse Transformer on Open Secondary Circuit. The Curve of Primary Electromotive Force is also shown.

to be accelerated in phase or brought more into synchronism with the impressed E.M.F. If, in addition, hysteresis is present the result will be to make the current curve unsymmetrical in shape as we see it is. As the load on the transformer secondary circuit is increased the primary current curve is brought back more and more into synchronism with the primary impressed E.M.F., and in its final position it comes into almost exact opposition with the *secondary* electromotive force, losing its unsymmetrical form and approximating more to a simple sine curve; and its harmonic analysis shows that as this loading up of the secondary circuit takes place the principal sine term of the Fourier series for the current becomes more important than the subsidiary terms.

When the transformer is fully loaded up on its secondary circuit we see that the secondary electromotive force lags a little behind the primary electromotive force, that is, it is not exactly opposite to it in phase. This is due chiefly to magnetic leakage. The primary current is under these circumstances almost exactly opposed in phase to the secondary electromotive force. Under conditions of full load none of the curves of electromotive force and current depart very widely from simple sine curves, and at any rate the sine curve form is sufficiently correct to allow of the application of simple analytical treatment in developing the theory of the transformer and in calculations. The marked exception to this is the primary current at low loads or the magnetising current.

Prof. Ryan and Mr. Merritt repeated the same kind of experiments with a 40 light Westinghouse transformer, and also with a transformer having a core made of iron wire; but the general results as to the form and relative phases of the current and E.M.F. curves were found to be of the same character as in the above experiments.

Messrs. Humphrey and Powell also studied, by this method, a 40-light Westinghouse transformer, and found the loss on open circuit to be only one-half that of the 10-light. Its efficiency at the full load was 96·2 per cent., equivalent to an all-day efficiency of 90 per cent. This improvement is due to the use of a better grade of iron.

(To be continued.)

VERTICALLY-LIT LIGHTHOUSES.

The following article appeared in the *National Observer* of Saturday last, over the signature of "Kenneth Cornish":—

That eminent mechanician and man of science, the late Lieut.-Colonel Alexander Strange, F.R.S., who was the grandson of Scotland's great Jacobite engraver, Sir Robert Strange, and inherited his grandsire's delicacy of touch and vision, had a favourite saying: "Everything that is is wrong." Though at first sight paradoxical, there is a marvellous amount of truth in it, especially as regards scientific theory and practice. The whole history of scientific progress proves it, for most real discoveries have had bitter and powerful enemies in those whose preconceived notions were thereby traversed. In comparatively modern times, Harvey and Jenner in medicine, James Watt and George Stephenson, Arkwright, and the grand company of industrial inventors, attest the fact. The truth of Colonel Strange's apophthegm was illustrated by the success of experiments in the vertical illumination of clouds during the last three months of the Royal Naval Exhibition. Ever since the old-fashioned beacon as employed by night to warn mariners off dangerous rocks and coasts was quenched by the men of science who revived the old Greek Pharos as the modern lighthouse, much ingenuity and cash have been expended to prevent the rays of light employed from passing upwards, or in any save a horizontal direction. The endeavour has been made to rear very lofty lighthouses, crowned by lanterns—now mostly of the revolving type—carrying lights of enormous intensity, which pass into the night in a horizontal direction through lenses of immense and constantly increasing power and cost, the nominal power being estimated at a maximum at St. Catherine's of six millions of candles, and at the Eddystone of five millions. The photometer, on the basis of which these figures are estimated, is a most illusory instrument, however, as it merely gives the relative intensities of lights on an arbitrary scale; the more important quality of diffusibility it ignores, while traders on the so-called candle-power carefully omit to say—probably few of them know—that this diffusibility diminishes in a regular ratio with the square of the intensity. Now, the extreme distance at which Eddystone light is visible from a ship's deck on a clear night is stated to be seventeen and a-half miles; and probably the reflection from the few rays which manage to escape at its crown may be seen as a kind of halo some miles further, the lantern being about 180ft. above water-level at high tide—just that of the truck of the most useful old 74-gun line-of-battle ship.

The cost of building and maintaining the lighthouses on our shores is very onerous, and all save those interested in maintaining the present system by the powerful *argumentum ad crumenam* must rejoice at, and do their utmost to support, an infinitely cheaper and at the same time much more efficient scheme. A young Scots shipmaster, Captain Robertson, of the "Mogador" s.s., by a brilliant inspiration, came to the conclusion that a light sent vertically upwards would not only be seen as a bright pillar against the horizon, but illuminate the clouds above it, and thus be visible at a greater distance from the sea and other levels than any horizontal light, however powerful. He saw—what was evident when he had once pointed it out—that, even in fog, the vertical light would be far more easily seen than the horizontal, though the vessel herself were enveloped in the mist, because the curtain thins rapidly on leaving earth or water, and does not rise more than

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300ft. at the outside. It rarely happens in the thickest fog that one cannot see the main-truck from the quarter-deck, while the mainmast itself is quite invisible. A mile or so of fog will absorb the most powerful light, which will not, however, be invisible to vessels in clear water outside the belt of obscurity. Yet the vessels in the haze would be able to descry all but the lower rays of a vertical light. Captain Robertson communicated his discovery at the end of June to his friend, Captain A. G. Froud, Lieutenant R.N.R, the secretary to the Shipmasters' Society, who consulted the writer about it, with the result that the matter was at once laid before Lieutenant Lionel Wells, R.N., at the Royal Naval Exhibition; and this officer, being a man of science and learning, did not lose an hour in putting the theory to the test. The same evening he sent beams of light upwards in our presence, and the results exceeded our sanguine expectations. The first he projected, at an angle of about fifteen from the zenith, as a broad belt from the Admiralty search-light at the side of the little glass house on the lake, whence he directed torpedo operations and other manœuvres. It went up, as far as we could estimate then—and later experience showed we had greatly under-estimated the distance—about 500 yards, and illuminated a passing cloud at the lower level very distinctly. He then narrowed the beam into a beautiful pencil of light, that we estimated at 1,000 yards in length, which caught a cloud on the higher level. Finally, he managed to adjust the instrument so that the light-pencil became vertical. The effect was extremely fine; but in about half a minute the mirror was broken by the intense heat of the melting carbons. These lights were seen distinctly at Wimbledon. Lieutenant Wells repeated the experiments till the Exhibition closed, the results being watched by volunteer observers. The lights were clearly visible at Frant, 34 miles away, although they were only set at an angle of 15. Had they been vertical they would have been visible for 50 miles at least. The light used in these experiments was estimated at 6,500 candles intensity, that of the model of the Eddystone in the grounds being really of about 300,000 candles intensity. Though *caviare* to the general, these experiments were of interest and value to experts and scientific seamen, and were, perhaps, the most important of the many good works done at the Exhibition.

They attracted the notice of the Admiralty, the Trinity House, and Thames Conservancy, as well as the Board of Trade and Lloyd's; but hitherto it has not been possible to show the most valuable feature of the discovery, by placing an absolutely vertical light in a suitable position for observations to be taken at sea. The data which a beam of light going up some thousands of feet vertically—it must be absolutely vertical—would give for the determination of a ship's position is such that in tolerable weather the distance should by trigonometrical observation be fixed to a cable's length. There is no difficulty in the construction of a suitable apparatus at a small cost, and an admirable site and opportunity for the erection of the first vertical light for maritime service have occurred to the writer. The erection would be in many respects a suitable memento of the Royal Naval Exhibition, and of the fact that the first vertical light experiments were conducted within its bounds. An octagonal column near Portisham—about two miles from the Chesil Beach, on a hill 790ft. high, which dominates the Portland Bill and commands the Great Bridport and Weymouth Bays—was erected by public subscription to the memory of that Dorset man, Admiral Sir Thomas Hardy, flag captain to Nelson, who died in his arms. It was planned as a lighthouse by the architect, the late Arthur Acland, brother of the venerable Sir Henry Acland, Bart., Regius Professor of Medicine to the University of Oxford, and is owned by Mr. William Manfield, of Portisham, who is the descendant of one of Hardy's three daughters, the sole survivor of whom is Lady Macgregor. Visible from the sea for about 50 miles, the monument, which is falling into ruin, is even now a valuable landmark by day. Experienced seamen say that a vertical light placed at this point would be of enormous value, as the coast is one they dread and shun even more than St. Catherine's Point. It is estimated that the tower could be repaired, a caretaker's cottage built, and the necessary apparatus for a sufficiently powerful vertical light set up, for between £1,000 and £1,200. The idea has been broached and favourably received in Dorsetshire, by Mr. Manfield and all to whom it has been suggested, and no doubt the County Council would vote a sum for the work if it were backed up, as it should be, by the Government departments, the great steam-shipping companies, and the railway companies which have sea lines, as well as by Lloyd's and other mercantile bodies. The saving in life and property if this new system does half what is expected of it would be simply incalculable. Meantime, it looks very much as if it supported the dictum of Colonel Strange.

BOOKS, &c., RECEIVED.

"Electric Light Cables and the Distribution of Electricity." By Stuart A. Russell. The Specialists' Series. (London: Whittaker and Co.).

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, January 22nd.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "On the Driving of Electro-magnetic Vibrations by Electro-magnetic and Electrostatic Engines." By Prof. G. F. FitzGerald, F.R.S. (2) "On Supplementary Colours." By Prof. S. P. Thompson, F.R.S.

ROYAL INSTITUTION.

9 p.m. Evening discourse: "The Composition of Water." By Lord Rayleigh, F.R.S.

SATURDAY, January 23rd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Induction Coil and Alternate Current Transformers." By Dr. J. A. Fleming, M.A.

MONDAY, January 25th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. II.—1. "Developments of Electrical Distribution." By Prof. George Forbes, F.R.S.

TUESDAY, January 26th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed: "On Weighing Machines." By Wilfrid Airy, B.A., M.Inst.C.E. After which the President and Council will hold a reception in the Library.

WEDNESDAY, January 27th.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Annual General Meeting. Election of Officers. Presidential Address by Baldwin Latham, M.Inst.C.E.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "The Scientific Value of Lovibond's Tintometer." By F. W. Edridge-Green.

THURSDAY, January 28th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Presidential Address on "Electrotechnics." By Prof. W. E. Ayrton, F.R.S. (Postponed from the 14th inst.)

UNIVERSITY EXTENSION SOCIETY.

8 p.m. Lecture at Public Library, Lavender Hill, on "Recent Applications of Electricity." By Dr. J. W. Waghorn.

FRIDAY, January 29th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Papers to be read: (1) "The Evolution of Rotating Projectiles." By William H. D. Cleminson, Stud. Inst. C.E.; (2) "The Manufacture of Forged Steel Projectiles." By D. Carnegie, Stud Inst. C.E.

ROYAL INSTITUTION

9 p.m. Evening Discourse. "Tales of the Scottish Peasantry." By Sir George Douglas, M.A.

SATURDAY, January 30th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "The Induction Coil and Alternate Current Transformer." By Dr. J. A. Fleming, M.A.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Purification of Water by Electricity.—Dr. Fermi, of Munich, has been testing the Webster method of purifying water by electricity. The dissolved organic substances are reduced about one-half, and the suspended substances are either precipitated to the bottom by the ferric hydrate formed on the surface of the iron electrodes, or gather on the surface of the water. The smell of the water is also perceptibly improved. After detailing the process and explaining the chemical action that arises during the purification, Dr. Fermi says that the organic substances contained in a litre of water can be reduced by two-thirds in one hour by an electric current of 0·5 to 1·9 with ampere flat iron electrodes 80 sq. cms. and 5 cms. apart. The number of germs is thus diminished fifty or one hundred-fold. The purifying effect of such current, however, is less reliable than that of the addition of 1 per cent. of lime, which completely frees the water of germs and keeps it free, whereas in the electrified water the germs multiply again fivefold in forty-eight hours.

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The Electrician.

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THE DEVELOPMENT OF PRACTICAL GEOMETRY.

In the two letters which Mr. LANGLEY has sent us, the question raised by Mr. OLIVER HEAVISIDE as to the doings of the Association for the Improvement of Geometrical Teaching has been fully answered. In inviting this information we must confess that we were not so much concerned with the better teaching of geometry as with the development of that science. It has always appeared to us that there are two distinct kinds of mathematical mind, the geometrical and the analytical; but this is denied by many mathematicians. They say that the two are as inseparable as melody and harmony, and that a mind which is content with geometry to the exclusion of symbolic mathematics is to be compared to a musician who can take pleasure in playing the Hallelujah Chorus on a flute. The metaphor is a bad one. One man cannot manipulate a whole orchestra, and very few performers are privileged to produce more than one note at once. However that may be, the value of the application of geometry to electrical work is inconceivable to those who have had no practical experience in it; and while graphics are taught by Prof. ROBERT SMITH, and by Prof. KARL PEARSON, and a few others, progress is only being made in this direction by those who use geometry for practical work. Nineteen schoolmasters out of twenty, and almost as large a proportion of professors, are content to teach what they call geometry out of a book written for the schools of Alexandria sixteen hundred years ago. Euclid is not useless; but its real value to-day is for teaching logic, not geometry. HOBBES studied Euclid; but his habit of mind was analytical, and not synthetical. He therefore began at the famous forty-

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seventh proposition, and worked backwards to the beginning, after which he was, no doubt, in a better position to appreciate the definitions, axioms, and postulates than most students who attack these first. But most minds are inclined to inductive and not to deductive reasoning. Students of science, more particularly, perhaps, those who turn their attention to physics, are more interested in pioneering advance, and in drawing inferences from observed phenomena, than in groping backwards from experience for causes which may make that experience rational.

For educational purposes, the building up of knowledge step by step is obviously best as a general principle, while the analysis of a problem is an excellent test of knowledge already acquired. A vast majority of mathematical work appears at first to be analytical; but, on closer examination, it will generally be found to be made up of synthetical constructions. A schoolboy is first invited to exercise his powers of guess-work when he begins to do simple division, and to a greater extent when he extracts square roots. The process is a succession of guesses, each step supplementing the last, and correcting the error. Algebra is full of guess-work, which has to be done according to laws. The real meaning of these restrictions, if ever carefully taught, is generally quickly forgotten, and the work proceeds, just as a game is played, by rules. In the working of the differential and integral calculus the guess-work and the rules are more prominent than ever, and the higher the problem, the more important part does guess-work play, while the real signification of "the rules of the game" is so often lost, that if we stop a mathematician in the midst of his work, and ask, "But why do you suddenly introduce $\log_e a$, when no logarithms have been mentioned?" he will reply, "Oh! that is one of the things you *have* to do, one of the first things you learn in integrating." It is indeed one thing to carefully study the meaning of each of these dodges, and it is another thing to have them ready for use at one's finger ends. To attack a problem by algebraic or so-called analytical methods may be compared to the entry of an unknown fortress by means of a bunch of keys. Each trick of manipulation or other "well-known substitution" is a key, and the proper one has to be selected for each locked door that is met with. The reasons for the shape of each key, the number and the form of its wards are forgotten, if indeed they were ever studied. It might be thought that, with patience, anybody might go through the whole bunch one by one, until the bolt was shot. Not so in mathematical work: he who would successfully wield the key must know how to manage the levers and coax the tumblers; he must know when the door has been opened, and which way he must turn next. But it is possible to enter a fortress by another route than a labyrinth of dark passages and locked doors. It is possible to penetrate to its innermost court without once losing sight of the light of day or of the direction of march. A straight ladder or two is all that is needed, with a little agility, some constructive skill in placing them in effective positions, and mechanical instinct in the best way of bridging wide gaps. With the destination always in view, and a clear reason for each step, this process is to many minds more satisfactory. By this route we "get there," though it may sometimes be a little roundabout. Geometrical construction is the name of this route, and as yet it is hardly to be dignified by the name of mathematics.

Graphics are treated by many mathematicians as a specially prepared food for infants; strong meat cut up small for feeble digestions. They look rather condescendingly on such methods as not fit to be classed with either pure or applied mathematics, but as useful helps for ignorant engineers. After all, nothing more is wanted than plenty of straightforward geometry. We have constructive geometry and descriptive geometry, and some other minor branches; but a large part of the subject is composed of such useless stuff as conic sections, pedal curves, and the like. These may have some educational value as pure mathematics, but we are dealing at present with practical applications, and maintain that a large number of engineers, though not all, could use geometrical methods, if they only knew how, to solve many problems which they now shirk for the simple reason that their algebra is rusty from long disuse. In a geometrical construction, little is, as a rule, assumed, and there are very few tricks. Take the case of solid angles as an example. A student has the expression $2\pi\ (1 - \cos\theta)$ flung at his head; and whether he understands it or no, he finds that it is one of the proper keys to use in dealing with solid angles. During his classical studies rather than his mathematical, he will perhaps hear of the figure which Archimedes desired should be cut on his tombstone, a sphere inscribed within a cylinder, to commemorate his discovery that the two curved surfaces were equal. The proof of this, for proofs are wanted for educational purposes, is as charming as the $2\pi\ (1 - \cos\theta)$ is repulsive; and it is not until the former is mastered that the latter can be appreciated.

In many books a section is devoted to curve-tracing. During the past ten years electrical engineers have become well accustomed to curves, and handle them and their axes and asymptotes in a way which must horrify some mathematicians. They plot curves for the purpose of arriving at certain results; and, stepping in where angels fear to tread, "they get there," while the analytical mathematicians are still floundering after a formula. How little is to be found in text-books on the various ways of setting about to find the rational formula, or even an empirical formula for an observed curve!—another instance of the comparative unpopularity of deductive reasoning. Some dodges are taught at technical colleges, but as yet this is not considered as part of practical geometry. The "clock-face" methods of Blakesly and Kapp are examples of a most useful application of geometry to problems which are simply bewildering in symbolic notation, and a hitherto unpublished polar method on Zeuner's valve-diagram principle has been devised by Prof. S. P. Thompson, to include other periodic fluctions than simple harmonic ones. In the subjects of the practical properties of conic and polar curves alone, there is a wealth of useful information unknown to nine engineers out of ten; and the tenth has laboured through theorems and problems of a purely academical character, and has only found them scattered here and there through sundry books. We have marked some of them with blue pencil, as being the only parts worth having in certain text-books. A dictionary of the characteristics and properties of curves, with a few practical corollaries, like Carr's Synopsis, but one-tenth the size, would be very valuable. Proofs would be as much out of place in such a book as in Molesworth.

We do not appeal to men who prefer to "play upon the symbols." At least one well-known engineer prefers a double column of figures to a curve plotted from them, and more than one of our valued contributors prefer a fine flowing formula to a geometrical figure. But we appeal to those who, like the members of the Association for the Improvement of Geometrical Teaching, may be able to move the whole mathematical school of this country, to improve not only the method of teaching of geometry set forth by Euclid, but to infuse into geometry itself some of the spirit of his mighty contemporary Archimedes, and to place in the hands of engineers and physicists an operator which, if not as powerful as any algebraical calculus, is one which can be handled by the plain man.

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THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 273.*)

§ 52. **Maxwell's Method.**—In order that we may be able to calculate the action of one coil on another, we must know M, the coefficient of mutual induction for the two coils. Maxwell gives a very general expression by which we can calculate M to any accuracy required. To fully understand Maxwell's process requires a knowledge of the elements of Spherical Harmonics. As we do not assume this knowledge on the part of our readers, we shall only explain Maxwell's result. Suppose, then, that we have two coils of radii A and a, and that they are so placed that their axes* meet at an angle θ in a point O (Fig. 46).

Maxwell shows that

$$M = G_1 g_1 P_1(\theta) + G_2 g_2 P_2(\theta) + \ldots \ldots$$

where the big G's depend upon the dimensions of A, and the distance of its centre from O, and the little g's depend in a somewhat similar manner upon the smaller coil. A is supposed to be greater than a. The quantities $P_1(\theta)$, $P_2(\theta)$, &c., are

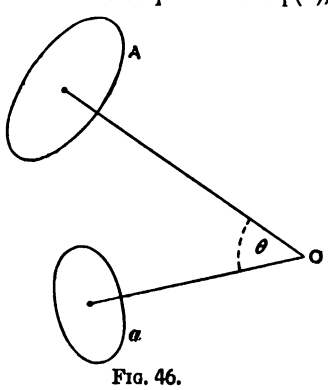

Fig. 46.

Zonal Harmonics; they are simply functions of θ, whose values can be found by the aid of a table of sines and cosines. Thus—

$$P_0(\theta) = 1,\ P_1(\theta) = \cos(\theta),\quad P_2(\theta) = \tfrac{1}{2}(3\cos^2\theta - 1)$$
$$P_3(\theta) = \tfrac{1}{2}(5\cos^3\theta - 3\cos\theta).$$

A table of their values for successive values of θ is given by Prof. John Perry in the *Phil. Mag.*, Dec., 1891. It is important to note that when $\theta = 0$ $P_0 = P_1 = P_2 = \ldots = 1$.

§ 53. **Zonal Harmonics.**—These functions are extremely useful in many physical problems. A study of Chapter XIV., Vol. II., of Maxwell's treatise will show the student that it would be very hard to imagine that there could be any set of functions better adapted to express the physical facts than Zonal Harmonics. The following may serve to give some ideas as to their nature. We know (§ 17) that the magnetic potential of a pole of strength m is $V_0 = m/r$. Again, the potential of a "small" magnet of length l and pole-strength m is $V_1 = m\,l\cos\theta/r^2 = m\,l\,P_1(\theta)/r^2$, where θ is the angle between the axis of the magnet and the radius r. Let O be the centre of the magnet. Let us now move the magnet in the direction in which its north pole points through a distance $l/2$, and then place a second magnet exactly equal to it in all respects, with its centre at a distance $l/2$ on the opposite side of O, and pointing in the opposite direction. If we determine the potential of this new system, we find $V_2 = 2\,m\,l^2\,P_2(\theta)/r^3$. We can do this by a method similar to that of § 18; but in applying it we must remember that θ changes as well as r. If we repeat this operation with this last system and place on the opposite side of O a second system in which the signs of all the poles are reversed, we find that $V_3 = 2\times 3\,m\,l^3\,P_3(\theta)/r^4$, and so on. If we examine these different cases we see that they are equivalent to systems of isolated poles.

Thus V_0 is the potential of a single pole m, V_1 that of two poles $+m$ and $-m$, V_2 that of poles $+m$, $-2m$, $+m$, and so on, the various cases being shown in Fig. 47. The coefficients in the nth case are those of the successive powers of x in $(1-x)^n$. The potential of any system of magnets or currents which is symmetrical about an axis can always be expressed as a series of Zonal Harmonics with suitable coefficients.

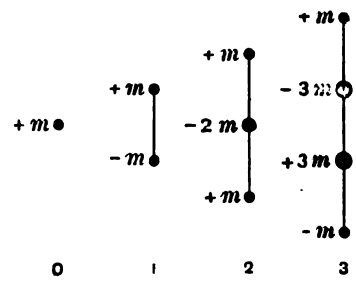

Fig. 47.

§ 54. **Values of G and g.**—These quantities can be found in the following manner. Let B be the distance of the centre of the coil from the point O (Fig. 48),* and let $C^2 = A^2 + B^2$. Let x be the distance from O of any point Q on the axis. Maxwell shows that as long as x is small compared with C, the magnetic force at Q for unit current is $F = G_1 + 2\,G_2\,x + 3\,G_3\,x^2 + \ldots$ Hence, to find the big G's we determine by the aid of § 26, or otherwise, the magnetic force at Q, and expand it in *ascending* powers of x. We then equate the coefficients of the powers of x in the two series, and thus find G_1, G_2, &c. To find the little

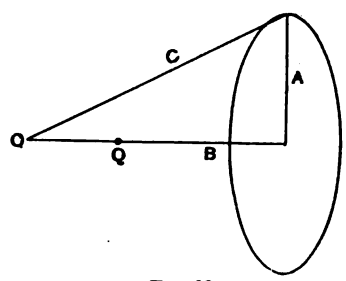

Fig. 48.

g's we proceed as follows:—Let b be distance of centre of the coil from O (Fig. 49), and let $c^2 = a^2 + b^2$. Maxwell shows that if Q′ is a point on the axis, and O Q′ $= x$, then, when x is large compared with c, $F' = 2\,g_1/x^3 + 3\,g_2/x^4 + 4\,g_3/x^5 + \ldots$ F′ being the magnetic force due to unit current. Expanding the expression obtained by § 26 in *descending* powers of x, and

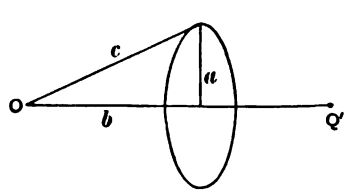

Fig. 49.

equating the coefficients of the powers of x in the two series, we obtain the values of g_1, g_2, &c. In this way we find

$$G_1 = 2\pi A^2/C^3,\quad G_2 = 3\pi A^2 B/C^5,\quad G_3 = 4\pi A^2 (B^2 - \tfrac{1}{4}A^2)/C^7,$$
$$G_4 = 5\pi A^2 B (B^2 - \tfrac{3}{4}A^2)/C^9,\quad g_1 = \pi a^2,\quad g_2 = 2\pi a^2 b,$$
$$g_3 = 3\pi a^2 (b^2 - \tfrac{1}{4}a^2),\quad g_4 = 4\pi a^2 b (b^2 - \tfrac{3}{4}a^2).$$

If we have a pair of fixed coils as in the Helmholtz arrangement we require to know the values of the big G's at the centre of the system. There are two cases to consider, since the current may circulate in the same or opposite directions in the two coils. We take first the case where they flow in the same direction.

It is clear that if G_1', G_2' . . . refer to one coil and G_1'', G_2'' . . . to the other, then $G_1 = G_1' + G_1''$ $G_2 = G_2' + G_2''$, and so on.

* The *axis* of a circle is a line through its centre at right angles to its plane.

* In Figs. 48 and 49 all the lines are *in* the plane of the paper, with the exception of the circles, which are supposed to be at right angles to that plane.

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Thus if the two coils are exactly equal and placed at equal distances from O we have

$$G_1 = 4\pi A^2/C^3, \quad G_2 = 0, \quad G_3 = 8\pi A^2 (B^2 - \tfrac{1}{4} A^2)/C^7, \quad G_4 = 0,$$
$$G_5 = 12\pi A^2 (B^4 - \tfrac{3}{2} B^2 A^2 + \tfrac{1}{8} A^4)/C^{11},$$

since G_1, G_3 . . . are not affected when we change B to – B.

In a similar way if the currents flow in opposite directions in the two coils we must change the sign of G_1'', G_2'', &c., before addition. Thus we have in this case

$$G_1 = 0, \quad G_2 = 6\pi A^2 B/C^5, \quad G_3 = 0, \quad G_4 = 10\pi A^2 B (B^2 - \tfrac{3}{4} A^2)/C^9.$$

§ 55. **Application to the Electro-Dynamometer.**—Returning to this instrument, we see that when the origin O is taken at the centre of the suspended coil, since the current flows round the two coils in the same direction, G_2 G_4 G_6, &c., vanish. When the Helmholtz pattern is adopted for the fixed coils G_3 vanishes, since then B = A/2. Thus, the expression for the coefficient of mutual induction reduces to the following—$M = G_1 g_1 P_1(\theta) + G_5 g_5 P_5(\theta)$. Since the product $G_5 g_5$ is small compared with $G_5 g_5$, we need generally only retain the terms written above. Now, since ϕ is the angle of deflection of the suspended coil $\phi = \pi/2 - \theta$. When ϕ is small, so that $\theta = \pi/2$ nearly, $P_5(\theta) = \frac{15}{8} \cos\theta$, while $G_5 = -\frac{144}{625} G_1/A^4$, and for a single suspended coil placed at the centre, where $b = 0$, $g_5 = \frac{5}{8} a^4 g_1$. Thus very nearly

$$M = G_1 g_1 \sin\phi \{1 - 27\, a^4/100\, A^4\}.$$

The couple experienced by the suspended coil is

$$i^2 \frac{dM}{d\phi} = G_1 g_1 \cos\phi (1 - 27\, a^4/100\, A^4).$$

Hence we can correct our previous approximation by multiplying by the factor $1 - 27\, a^4/100\, A^4$.

The suspended coil is sometimes made in two halves, which are arranged in the Helmholtz fashion. In this case g_3 vanishes. The advantage gained by this construction is as follows:—On account of the finite space occupied by the windings on the large coil, G_3 does not completely vanish, but by making g_3 vanish, we get rid of the product $G_3 g_3$ entirely. The instrument at the Cavendish Laboratory which is figured in Maxwell, Vol. II., p. 339, is arranged in this way. By this arrangement g_5 becomes $-\frac{5}{16} g_1 a^4$, so that the correction depending upon g_5 is slightly greater than when the simpler pattern is adopted for the suspended coil.

§ 56. **Practical Example.**—As an example of the use of the electro-dynamometer in "absolute" measurements, we may quote the work of Mr. Dugald McKichan on "The Determination of the Number of Electrostatic Units in the Electromagnetic Unit" (*Phil. Trans.* Royal Soc., 1875). The research was carried on at Glasgow University.

Here the fixed coils conformed closely to the Helmholtz pattern, while the suspended system was a single coil. The mean radius of the large coils was about 16cm., and the mean radius of the small coil about 4·2 cm. The correction depending on $P_5(\theta)$ is just appreciable in this case, but no account was taken of it in the calculations; it amounts to about 1 part in 780 in the value of i^2. There were on the two large coils together 7,389 turns of wire. The value of g_1 which was found by comparison with the large coils, was about 195,000 sq. cm. The instrument was adapted for the measurement of very small currents, a deflection of one scale-division ($= \frac{1}{10}$ inch) at a distance of 446cm. from the mirror corresponding to a current of about ·00002 C.-G.-S. units or ·0002 amperes. Since the current is proportional to the square root of the deflection, it follows that the deflection of about 400 scale divisions, which was generally obtained, corresponded to about ·0004 C.-G.-S. units, or ·004 ampere. The suspended coil was not hung by a bifilar suspension, but by a single wire, the electrical connexions being completed by a fine wire coiled into the form of a spiral spring, and attached to the lowest part of the suspended coil. The experimenter considered that the deflection, θ, was so small that its square might be neglected compared with unity. The error introduced on this score only amounts to one part in about 3,000; and, under these circumstances, sin θ and θ may be considered identical. In order to diminish the differences in the readings which arise in consequence of the earth's action, magnets were arranged so as to neutralise the earth's magnetic field at the centre of the instrument as nearly as possible.

We have now said sufficient about the electro-dynamometer, and shall go on to consider with greater exactness than in § 48 the theory of the "current-weigher."

(To be continued.)

RADIATION OF ELECTRIC ENERGY.*

BY FRED. T. TROUTON.

(Concluded from page 281.)

In Fig. 3 is shown one of Prof. Hertz's original pattern radiators; is in principle the same as the one in Prof. Lodge's experiment. The square metal plates to right and left correspond to the outside and inside coating of the jar. It differs in the current alternating somewhat more rapidly. The time elapsing between each swing is about $\frac{1}{300,000,000}$th part of a second. That is to say, if the oscillations continued for one second, 30,000,000 would have taken place. In order to form some idea of the stupendous rapidity with which they succeed each other, I may mention that a clock ticking once every second would require to be kept going for 347 days (almost a year) before its pendulum would have performed the number of vibrations that would here take place in one second. As a matter of fact, only a dozen or so of these vibrations really occurs, so rapidly is the energy radiated, each one being less than the last, like the vibrations of a string of a musical instrument.

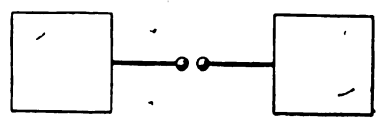

FIG. 3.—Form of Hertzian Radiator.

Just as in Prof. Lodge's experiment, a spark is produced in a receiver identical in form with the radiator, placed at some little distance away; but as this is small, it is often convenient, when wishing to exhibit to a number at once, to use a sensitive current detector with a spot of light in the usual fashion; for by its means, curious enough to say, we are able to see when the receiver is affected. The wires leading to the detector are connected one to either plate of the receiver.

Non-transparent objects, such as metal sheets, can cast shadows and stop their electric radiations just as they would with light. As a rule, things which stop light stop these radiations, and things which let light through let them through also. In this respect, and in many others, which we will refer to later, there is the greatest resemblance between the properties of light and of these electric radiations. Maxwell many years ago anticipated such, and suggested that light itself was but an electric radiation, with an extremely high rate of alternation. Amongst other reasons brought forward for supposing this was that the speed, calculated from purely theoretical considerations for electric radiations, agreed precisely with what had been found to be the speed of light—180,000 miles per second. It remained, however, for Prof. Hertz to put the matter beyond all doubt by measuring the speed by actual observation; and we will now endeavour to see how this was done, by employing a rope as an illustration.

Suppose one end of the rope fastened to the wall, the other held in the hand, when the unattached end of the rope is given a shake, a wave is observed to pass up along it; and if one watches closely one will see that when the wave reaches the fastened end another wave apparently starts, and travels back along the rope. That is to say, the wave is reflected at the end, and comes back to us. (Fig. 4).

* The conclusion of a course of lectures delivered in Inverness, December, 1891, under the auspices of the "Ettle's Trust."

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By continuing to shake the free end at a uniform rate waves, consisting of a number of hills separated by hollows, can be sent travelling along the rope; each of these, of course, must be reflected at the fixed end, and ought thus to form a procession of waves passing back along the rope. But this is not as it will appear to us, for we must remember that what we actually see is the result on the rope of a continuous procession of waves going up to the end, as well as of those coming away after reflection.

The combined effect of these two processions of waves travelling in opposite directions, thus produced by reflection, is seen to be that there are a number of points along the rope, situated at equal distances apart, which remain at rest, and never go up to make a hill or go down to make a hollow. And if we think for a moment this is the only thing the rope could do; for each hill returning from the fixed reflecting end must at certain points meet the oncoming hollows, now the returning hill tends to raise the rope, while each oncoming hollow tends to move it downwards, the result is where they meet the rope has to remain at rest. Again, between these points the returning hill encounters an oncoming *hill*; and here, when this happens, the rope gets an increased swing up. It is in like fashion for two hollows, which are in truth but hills when viewed from the other side. In this way we see the rope is thrown into portions, which vibrate strongly, these portions of rope being separated by points which remain always at rest.

Now, the distance from one point of rest to the next is half the distance the waves travel in the time of one vibration, for it is obvious a returning hill is met on each occasion half way by an oncoming hollow; for they are both moving at the same rate and in opposite directions, so that, by measuring this distance, we can find the speed the waves travel at, provided we know the time taken for each vibration.

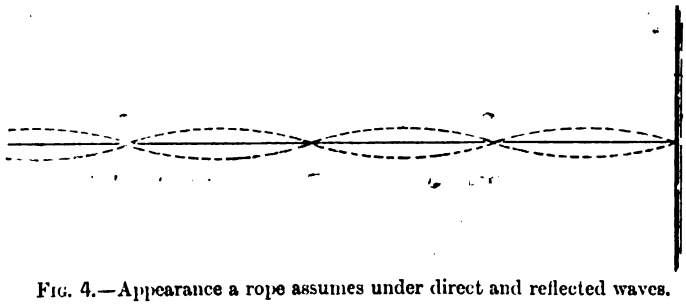

Fig. 4.—Appearance a rope assumes under direct and reflected waves.

It was after this fashion, then, that Prof. Hertz succeeded in determining the speed of electric waves. By means of a reflecting sheet of zinc the waves travelling in the opposite direction to the original ones were produced; and these at certain points destroy or neutralise each other's action, just as we have seen is the case with the waves on the rope.

In this way, then, by measuring the distance apart of these points, one is able to determine the speed these electric waves travel at, provided the time the current takes to alternate is known, and the way to ascertain this by calculation was shown long ago by Sir William Thomson.

Among some of the other points of resemblance between these electric rays and light, to which I alluded before, is (1) that these rays were found by Prof. Hertz to be bent to one side on passing through a prism, just as we know light to be by passing it through a glass prism. (2) Again, these electric rays are found not to be reflected by ordinary thin sheets of glass,* though thick sheets, or in that case, more properly speaking, walls of glass reflect strongly. This is quite in agreement with light for extremely thin sheets; for instance, soap bubbles, when just about to burst, reflect no light, as is well known; ordinary sheets of glass being equally thin compared to our long electric waves, as the thinnest soap bubble is to the minute waves of light.

Further, to make the likeness more complete, I may mention that when soap bubbles are viewed with mono-chromatic light (*i.e.*, light of one colour), as the sides of a bubble drain away and become thinner the bubble goes through stages of reflecting and of not reflecting the light, according to the thickness—that is to say, at a certain thickness there is reflection; at a little thinner than this there is none; at a little thinner again there is again reflection, and so on till the bubble bursts. In like manner walls—for such the thin sheets have to be in the case of these long electric waves—have been found to reflect or not to reflect according to their thickness after the same fashion.

Another, and perhaps a more striking resemblance, is that (3) both light and these electric waves refuse or allow themselves to be reflected obliquely from non-metallic surfaces, according to the direction they are vibrating in.

Without going further, we see there is abundant evidence to show the great resemblance between light and these electric waves. In fact, there can be no doubt but that they are in every way identical, excepting in so far that, in the case of light waves, the undulations succeed each other with exceeding rapidity, compared with the electric waves we have been dealing with.

We thus are brought to the conclusion that, could we only contrive an electric radiator after Prof. Hertz's plan, which would vibrate fast enough, and send out successive undulations at short enough intervals, we would have a source of illumination, for the radiation would affect our eyes, and be in every respect what we know light to be.

Many experimenters are at the present moment working at this problem from different directions, the great desideratum being the production of light without the simultaneous production of useless heat, which occurs in all the means we now employ for artificial illumination. Instances of the production of light without heat are to be found in the light emitted by many organisms, such as the glow-worm; and in the illumination afforded by certain substances after exposure to bright light, such are often put up in small tubes, and ornamental designs for the purposes of exhibition. After exposure to bright light they continue to glow for some time, although they remain quite cool.

Many of these substances also glow when placed in tubes exhausted of air, and an alternating electric current passed over them.

What we do here is apparently to give the molecules of these substances a great shake every now and then, they continuing to vibrate between each disturbance after their own fashion as little electric radiators, thus affording us light. Experiments lately made by Prof. Tesla, of America, seem to show that the more frequently they are disturbed the better. An ideal, of course, would be to give them a help each oscillation by a synchronous alternating current. Prof. Tesla has built an alternating dynamo, which afforded currents alternating 20,000 times a second; but this is far and away short of what would be required, if in truth such a thing is possible, as a circuit carrying a current alternating in periods comparable with that of light. The speed of rotation and the number of coils which can fit on a rotating disc seems nearly reached in his machine; but by combining the principle of the transformer with that of the dynamo, we could push the rate of alternation beyond these mechanical limits: for instance, by passing an alternating current through the field-magnets of an alternating dynamo instead of the usual continuous current.

We might suppose this done by having two machines on the same shaft, the first arranged as usual, while the field-magnets of the second derive their current from the armature of the first, and in such a way that when the armature coils and field coils are closest the current in the field coils should be zero. The current from the armature of the second machine would thus be of double the rate, for we have superimposed on the geometrical zero position of the armature coils which occur half way between two field coils, zero position situated *at* the field coils. The two machines might, of course, be combined, only in that case the field-magnets of our second machine rotate, and are in fact the armature coils of the first, while the second set of coils to form the second armature would remain at rest. Unfortunately, we cannot go on in the same fashion doubling the rate, only, indeed, adding subsidiary vibrations by further machines.

So far, the long electric waves, as distinguished from the short electric waves of light, are of a purely theoretic interest;

* As glass happens to absorb these long electric waves, it is not so suitable for making the experiment with as other dialectrics; but for convenience of expression is spoken of here.

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but no doubt they will be turned by man to subserve useful purposes. The great difficulty which lies in the way is, that the radiation produced by the automatic method with intermittent supply of energy, the only one yet used, is necessarily insufficient in intensity to be powerful at considerable distances, owing to the vibrations dying rapidly out, like that of a violin string. So that until some other form of apparatus is invented, to be supplied continuously with energy, so as to produce a continuous vibration, and to which we can harness on a 50-H.P. engine, and get a really powerful beam of these electric rays, there can be no great advance hoped for. Such an arrangement is, perhaps, possible through the device of affording two alternate paths for a continuous current, each of these being interrupted by a spark gap, and the arrangements being such that either spark in turn was magnetically blown out by the action of the current as soon as it had started; a definite resonant period, by the attachment of a condenser, being imposed, after the fashion of an organ pipe.

There is little doubt but that a powerful beam of this sort would, unlike light, be unabsorbed by fog; so, looking into the future, one sees along our coasts the light-house giving way to the electric house, where electric rays are generated and sent out, to be received by suitable apparatus on the passing ships, with the incomparable advantage that at the most critical time—*in foggy weather*—the ship would continue to receive the guiding rays.

It had often been a matter of surprise that human beings, the highest in the scale, were unprovided with electric organs of some kind or other, while other creatures of more humble type were so endowed; for instance, the electric eel with its destructive powers. But that we have electric organs, and those of a most beneficent nature, is now known; for science now shows us that our eyes are but resonant receivers of the minute electric waves which constitute light.

A LIGHTNING STROKE AT PREETZ.

In the *Elektrotechnische Zeitschrift* for December 25, 1891, Prof. Leonhard Weber describes the results of his investigations with regard to a lightning discharge which occurred in the afternoon of August 22, 1891, at the little town of Preetz, near Kiel. The storm consisted of a single flash, which was concentrated upon the church, although its effects were also visible in other parts of the town.

The church was provided with a lightning conductor put up in accordance with the latest ideas. One conductor ran direct from the point of the rod to an earth plate sunk eight metres in the ground. Another ran along the ridge of the roof of the nave, terminating on the one hand at earth plate II. and on the other at earth plate III., being taken over the chapel to it. Line No. 1 was connected to the gas pipes, and line No. 2 to the water pipes; the two lines being also connected together. A third conductor connected the other extremity of the ridge with earth. As to the metal work inside the building the following precautions had been taken. Both clock and bell were connected to line No. 1, and two long iron T pieces which crossed the belfry were joined at one end to the same conductor. Four large iron bars which ran across the nave were connected with the two metal rain-water pipes, one of which was in connection with one of the earth wires.

The resistances of the various circuits were measured, and the majority were not more than one ohm; one circuit, however, gave 21·6 ohms. This arrangement of conductors would appear therefore to have been erected according to leading principles. The conductors were sufficiently large, consisting as they did of 9mm. copper wire. All the salient points of the edifice were protected; and the water and gas pipes, as well as the metallic parts of the building, were in good connection with the lightning rod, the earth of which was excellent. Only the metallic wires which secured the ornaments of the nave were insulated.

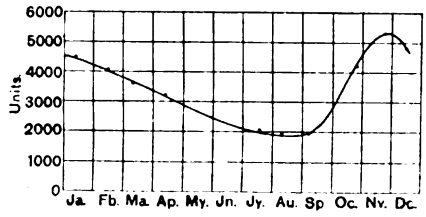
The following effects were visible. The silver tip of the lightning rod was partially melted, and the iron pipe surrounding the earthed portion of conductor No. 1 was melted for a quarter of its length, the mouth of the pipe being very markedly damaged. At the spot behind the organ where the two iron T's came into the interior of the church their extremities were much pitted. The ends of these iron T's were one metre away from the roof, which was also pitted along its entire length, and especially so in the vicinity of the iron bars traversing the nave. A discharge had therefore taken place between the metallic wires mentioned above and the iron. From this Prof. L. Weber concludes that the lightning would have had no effect if the two iron T's had been connected with iron bars crossing the nave. These long iron T's projected into the church like two gigantic branch conductors, being connected to the main conductor only at one end.

Prof. Weber concludes that the discharge must have been a slow one with a sudden increase of intensity: a rapid and oscillatory discharge being in his opinion out of the question by reason of the calorific effects observed, and a slow and steady discharge being equally so by reason of the injury done to low-resistance earth circuits. A slow discharge with a sudden increase of intensity would explain both the fusion of the silver tip and the lateral discharges. A second explication could be based on the fact that very often a discharge is not directed upon the large conducting masses of underground sheets of water or of gas or water pipes, but rather upon the damp soil surrounding a building. In the case under consideration the connection between the surrounding rail and the metallic portions of the building was mainly by the water pipes. There was, it is true, a metallic circuit running outside the water-piping to the belfry, and thence to the top of the conductor; but the shortest route was by the iron bars of the nave, the roof crossed in all directions by metallic wires, and the iron T's of the belfry; although it must be observed that there were gaps of 1 and 2 metres in this circuit.

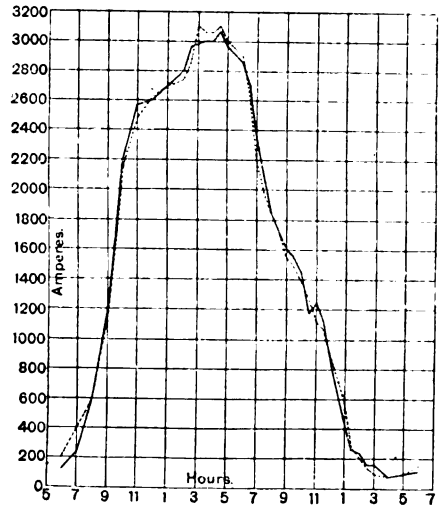
Whether we seek an explication of the effects observed in one or other of these ways, it is certain that if the number of conductors running to earth had been increased, the disruptive discharge within the church could have been prevented. Finally, it is to be remarked that the gas and water pipes were uninjured, which was to be expected. On the other hand, they would certainly have been destroyed if they had not been connected to the circuit of the lightning conductor.

SAMPLE LOAD CURVES OF THE ST. JAMES'S AND PALL MALL STATION.

We give below some load curves, which may be taken as typical of the demands made upon the St. James's Company's station for each month during the past year. The first diagram is deduced from the last twelve, and is typical of the *total* units generated in any one month of the year. The difference



1891.—Curve typical of the monthly variations in demand.



December 22nd.—Total units supplied, 7,942. (Deep Fog).

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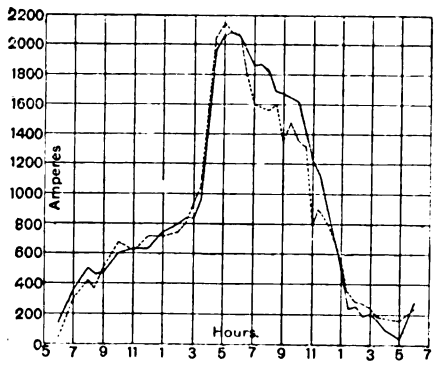
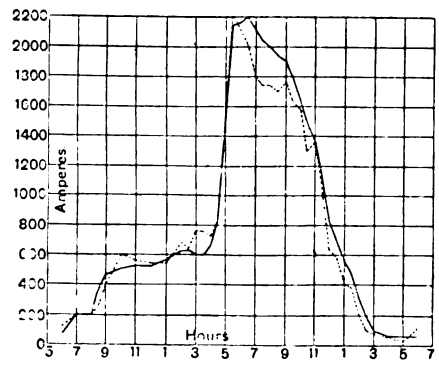
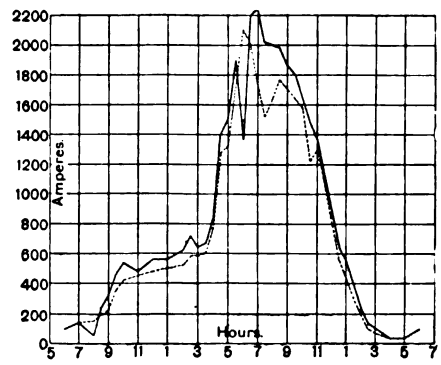
between the average demand in July and in November is very instructive; and in the case of the St. James's Company the additional lamps connected to the mains in the interval being insignificant, the November increase may be taken as due solely to climatic and meteorological conditions. The ample dimensions of the area enclosed by the second curve, which refers to Tuesday, December 22, 1891—a day of fog and darkness—may be contrasted with the last diagram of all, which shows a curve typical of the normal state of things in December. The full lines on the sample monthly curves show the current going out on one main, and the dotted lines give the current going out on the other main, so that the ordinates have to be added together to obtain the total output. The even balancing of the two circuits is worthy of notice.



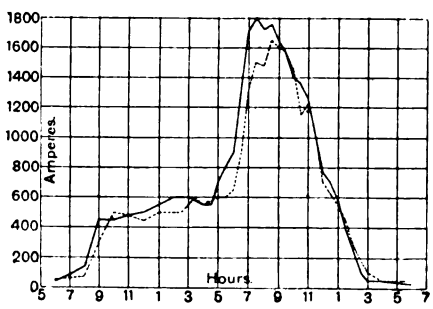
January 12th.—Total units supplied, 4,514.



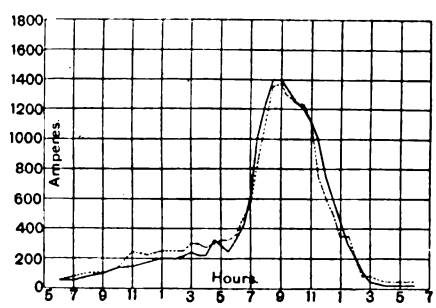
February 16th.—Total units supplied, 4,104.



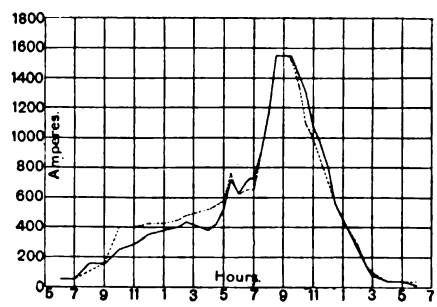
March 9th.—Total units supplied, 3,672.



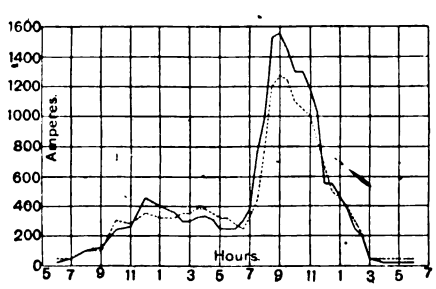
April 13th.—Total units supplied, 3,229.



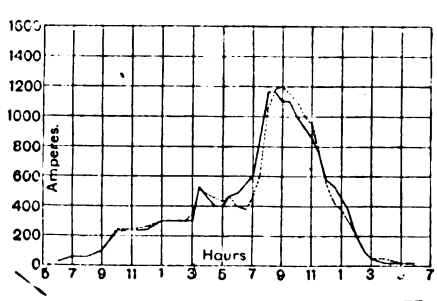
May 18th. –Total units supplied, 2,149.



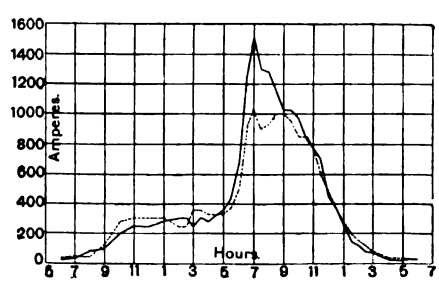
June 8th.—Total units supplied, 2,592.



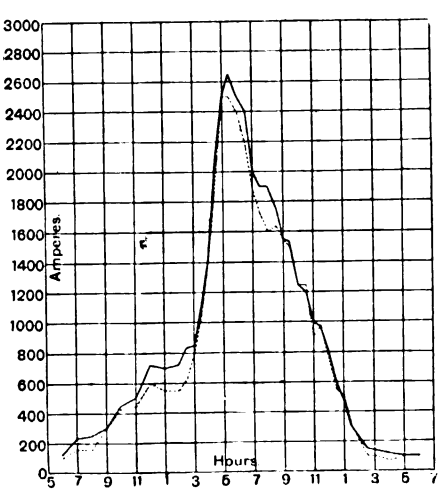
July 20th.—Total units supplied, 2,082.



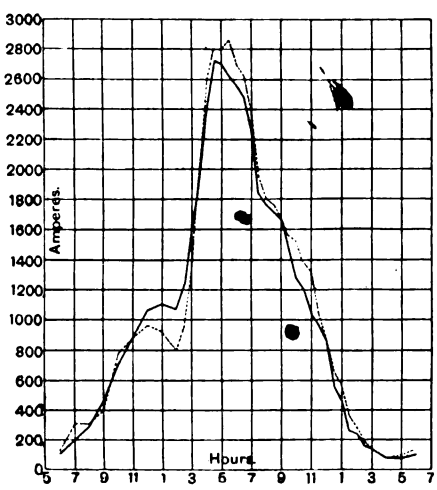
August 10th.—Total units supplied, 1,973.



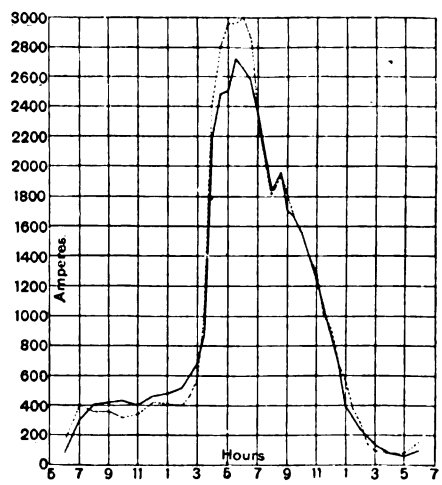
September 7th.—Total units supplied, 1,980.



October 26th.—Total units supplied, 4,267.



November 23rd.—Total units supplied 5,345.



December 14th.—Total units supplied, 4,822.

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THE NEW FRENCH CUSTOMS TARIFF.

The following extracts relating to electrical goods, from the New French Customs Tariff, which comes into definite operation on the 1st February next, may be of interest. In spite of careful search we have been unable to discover any reference to a tax on insulated cables, telephonic apparatus, switches, &c., although at one time the French electrical industry appeared to be demanding, all round, ultra protective duties, on the plea of restoring the commercial equilibrium. The London Chamber of Commerce inform us that the Minimum Tariff will apply to British products:—

Tariff No.	Article.	General tariff per 100 kilogrammes.	Minimum tariff per 100 kilogrammes.
		francs.	francs.
191	Graphite or Plumbago	Exempt.	
193	Bitumen	dito.	
200	Platinum and Gold—		
	(*a*) Ore	dito.	
	(*b*) Crude; in mass, bars, ingots, powder, broken up articles	10	10
	(*c*) *Thread, Sheet, or Wire.*—Fine drawn, simply laminated, in bars of at least 5mm. thickness, in sheets of at least 1mm. thickness, or as wire of at least 2mm. diameter	10	10
221	Copper—		
	(*a*) Ore	Exempt.	
	(*b*) *Pure or alloyed with Zinc or Tin*—		
	Crude; in mass, bars, pig, or sheet	dito.	
	Laminated, or beaten into bars or plates	13	10
	In wire of any dimension (polished or unpolished) other than gilded or silvered	13	10
224	Zinc—Sheet	4	4
238	Sulphuric Acid	Exempt.	
239	Lead Oxides—		
	(*a*) Minium	5	2
	(*b*) Litharge and other oxides	5	2
312	Carbons prepared for Electric Lighting	75	50
319	Glass Insulators	6	4.5
361	Incandescent Electric Lamps, capped (*munies de leur monture*)	400	350
361 (bis.)	Incandescent Electric Lamps, uncapped	800	700
475	Tubes and Conduits of Bitumened Paper	1.25	1
504	Large Clockwork. Clock movements, ditto telegraph instruments, counters, and every so-called clockwork movement, except that of a watch, complete or incomplete, with or without motor systems	100	75
505	Electricity Counters	100	75
510	Stationary Steam Engines, Heat, Gas, Petroleum, Hot Air, and Compressed Air Engines—		
	250 kilogrammes and more	18	12
	Less than 250 kilogrammes	30	20
511	Semi-Portable Steam Engines	17	13
524	Dynamo-Electric Machines—		
	1,000 kilogrammes and upwards	30	20
	50 kilogrammes to 1,000 kilogrammes	45	30
	10 kilogrammes up to and less than 50 kilogrammes	100	80
526	Steam Boilers, iron or steel, simple or furnished with feed water heaters, internal furnaces, but without tubes	12	9
526 (bis.)	Steam Boilers, iron or steel, tubular or semi-tubular, that is to say, having iron, steel, copper, or brass tubes	18	14
536	Armatures of Dynamo Electric Machines and separate parts, such as solid or hollow metal bobbins wound with insulated copper wire; worked copper pieces, weighing less than 1 kilogramme, numbered and marked, mounted or unmounted; intended for electric apparatus and arc lamps	100	75
576	Lead Piping, and all other kinds of lead work	4	3
576 (bis.)	Electric Accumulators	17	13
578	Worked Zinc, ordinary, united or stamped	12	8
620	India Rubber and Gutta Percha Materials—		
	(*a*) India rubber sheet; pure unvulcanised and vulcanised rubber thread	60	40
	(*b*) Belts, tubes, valves, and other India rubber and gutta percha work, pure or mixed, soft or hard, combined or uncombined with cloth or other material	90	70
634	Optical, Mathematical, Astronomical, and other Instruments of Precision	Exempt.	

APPLICATION OF ELECTRICITY TO THE DRILLING OF METALS.*

After some introductory remarks, the author went on to describe what had come within his own experience in the use of electro-motors in the drilling of metals. His firm used the size known as an inch driller, which was self-contained—that was to say, the electro-motor, wheel-gearing, drill-spindle, and electro-magnet were all carried on one framing; and the total weight of the machine and its framing was 314lb.; so that it was not too heavy to move, even by hand labour, from place to place. On the armature spindle of the motor there was a pinion-wheel, which geared with a spur-wheel on the second-motion shaft, another pinion which geared with a spur-wheel keyed on the drill-spindle. The motor and electrical connections were contained within a sheet-iron casing, and the pinions and spur-wheels were in a cast-iron box. In the machines used by the author's firm the motor spindle makes, on an average, 2,000 revolutions per minute, and the drill-spindle makes an average number of 125 revolutions per minute. This gives a ratio in the gearing of 1 to 16. The machine would be improved if the average number of revolutions of the motor were increased, as there would then be a larger margin to allow for differences in the sizes of the holes bored, variations in the electric current, and differences in the amount of feed put on the drill. The holding power of the electro-magnet is 1,650lb., which should also be increased; and the soft iron cores of the magnet are each 2⅝in. diameter, but they could be made larger, without in any way interfering with the handiness of the machines. At present it is possible, by screwing on a heavy feed on the drill, to slacken the grip of the electro-magnet on the work, and feeding had therefore to be done with some care so as to avoid such taking place. There was a difficulty in getting any reliable data as to the amount of pressure required to be exerted endwise on a drill when boring holes in metals. From some experiments made by a Glasgow firm, it was found that 916lb. pressure was required in boring mild steel with a drill ⅛in. diameter (the drill being flat on the sides); and 616lb. pressure was required with a drill of the same diameter, but having the edges feathered. In each case the drills were making 136 revolutions per minute, and had a feed of 312 turns per inch. Whatever might be the value of the results of the experiments referred to, it was found that a larger holding power was necessary in the magnet of a portable drilling machine, especially when boring upwards, in which case the machine had to support its own weight in addition to resisting the pressure on the point of the drill. It was also found in actual working that the best results were got by keeping the speed of the machine as high as possible and using a fine feed.

The main cables for the dynamo were led overhead through the boiler yard and sheds; and along the columns of the main building coupling pieces are placed on the cables, so that the current may be taken off and led by means of branch wires to the drilling machines wherever they may be employed. The current was from 12 to 14 amperes, and the voltage was 100. That was a comparatively safe current to employ, and in ordinary circumstances no one ran any danger in handling the machines. By means of a switch the man in charge could make the connection which threw the current into the electro-magnet, and fixed the motor in its required place against the object to be drilled, whether a separate plate or the side of a ship, or a boiler, or a girder. By a further movement of the switch he threw the current into the electro-motor working the drill; and by a handle at the back he fed the drill forward to the plate, and also while it was boring.

With a current of 12 amperes and a voltage of 100, the machine in ordinary working could bore a hole 1¼in. diameter through an iron plate 1in. thick, in an average time of two minutes, or a hole 1in. diameter through ¾in. steel plates in one minute 15 seconds. With an increase of current to 14 amperes, 1½in. holes were bored through 1in. iron plates in one and a-half minutes. Such tools as had been spoken of might not, in the meantime, be capable of doing the work any cheaper or any quicker than by present methods—although in many cases, if not in all, they would hold their own both for cheapness and for quickness in the execution. The great advantage gained in using them lay in the fact that they were portable; they could be taken to the mark wherever it might be, and they could be set on to attack the largest masses. They were specially useful for boring holes in out-of-the-way places, or within the areas of large plates, where no other form of machine driven either by power or by hand could, perhaps, be so readily applied. The electric drill was said to be specially valuable for boring the holes for the steam mountings and for other odd jobs about a boiler. A short time since the author noticed that a man bored a 2in. hole force feed check valve

* Abstract of Paper communicated to the Graduates' Section of the Institution of Engineers and Shipbuilders, Glasgow, by Sinclair Couper, Engineer.

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through a ¾-in. plate on the circumference of a boiler in four minutes, and he bored five holes for bolts in one minute each.

The author subsequently mentioned many interesting facts in connection with varied methods of working, and gave details as to comparative cost, all of which went to show that there were great advantages attending the application of electric energy for drilling metals, and similar purposes, and his decided conviction was that there was a great future for it in many directions.

MODERN APPLICATIONS OF ELECTRICITY TO METALLURGY.*

BY G. C. V. HOLMES.

During the last few years the application of electricity to lighting and to motive power had, said the author, received the greatest attention from the engineering profession, but comparatively little notice had been taken of the equally important application of this force to metallurgy and the manufacture of metal goods. At the present moment, however, the manufacture of copper goods by electrical methods was beginning to excite considerable attention in the engineering world. The author next proceeded to go into the elementary principles of electro-chemistry at some length, and then came to the practice.

Copper-Refining Apparatus.—The practical apparatus required to refine rough copper electrolytically was, he said, of the simplest kind. A boiler, steam-engine, and dynamo were, of course, indispensable. The electrical output was, of course, determined by the surface of anodes, which it was intended to expose in any one tank or bath, the usual allowance being a current of between 4 and 5 amperes per square foot of surface. The electromotive force of the current depended upon the number of tanks which it was intended to work in series, and on the average of the combined resistances per tank. With a well-arranged plant, the difference of potential between the anode and the cathode of each tank should be considerably less than half a volt. The tanks were generally made of wood, and measured about 3ft. in each direction. They were rendered acid-proof by being lined with lead, or some composition into which pitch enters largely. It was of the utmost importance that the tanks should be perfectly acid-proof, not only in order to avoid loss of the electrolyte by leakage, but also to ensure insulation. On the tops of the sides of the tanks at front and back were placed strips of copper, which served as conductors, and which are alternately connected. The anodes were square plates of cast rough copper. The cathodes were sheets of thin copper. Several anodes and cathodes were hung parallel to each other in each tank, and when a sufficient thickness of electrolytic copper was deposited on the cathodes they were removed from the bath, and the deposited layer was easily split away from the original cathode, which remained intact and ready for fresh use. The thickness of the deposited copper on the cathode was a matter principally affected by the capital at the disposal of the firm for locking up in raw material. The electrolyte was formed by dissolving 2lb. of sulphate of copper to each gallon of water, and adding 8oz. of concentrated sulphuric acid. The aim of the refiner was to procure a supply of rough copper containing a good proportion of gold and silver. Many brands of copper were exceedingly rich in the precious metals, and it was usual to allow a certain proportion of the assay value free to customers.

Cost of the Process.—The cost of the operation of refining copper was determined mainly by the difference of potential between the anodes and kathodes in each tank. The lower the latter, of course the less cost. It had been shown that with a pure anode, only sufficient electromotive force had to be provided to overcome the ordinary resistances, while with an impure anode an additional difference in potential was required to overcome the back electromotive force due to the accumulation of oxides on the anode, and a portion of the energy of the current was, of course, absorbed in oxydising the foreign metals present. It so happened that while it was easy by the old methods to refine rough copper up to, say, 98 per cent., it was very difficult by these methods to get it still purer. By the electrolytic methods on the contrary it was much easier to take the last impurities out than it was to refine a really rough copper. Thus the two methods might be said to be complementary to each other, and in practice it was desirable to bring the metal by the older, methods up to such a state that only about 2 to 3 per cent. of impurities remained in it. The principal resistance was in the electrolyte itself. This resistance could be diminished by reducing the length of liquid which the current had to traverse and by increasing its cross section, that was to say by bringing anode and cathode as close together as was found to be practicable and by exposing as large an area as possible.

It had been stated that in practice the difference of potential between terminals of any one tank was between one-half and one-quarter of a volt. Taking, however, the figure of two-thirds of a volt as a standard and briefly examining the cost of producing the current, at a consumption of 2·24lb. of coal per I.H.P. per hour, one ton of coal should give exactly 1,000 I.H.P. for an hour. Assuming the combined efficiency of engine and dynamo to be 75 per cent., a figure well within the limits of the best practice, the above engine-power should give us 750 electrical horse-power, or $750 \times 746 = 559{,}500$—watt-hours. Supposing, for the sake of simplicity, that the whole of the work was done in one huge tank, the conditions of which allow the current to be passed through with a difference of potential of two-thirds of a volt; there would then be a current of $559{,}500 \times \frac{2}{3} = 839{,}250$ amperes for an hour. A current of one ampere for a second could deposit 0·0003307 grammes of copper; therefore, the amount deposited by the same rate of current in an hour $= 0{\cdot}0003307 \times 3600 = 1{\cdot}19052$ grammes, and, therefore, the current of 839,250 ampere-hours can deposit $839{,}250 \times 1{\cdot}19052 = 999{,}140$ grammes, or almost exactly one ton of copper could be deposited by the consumption of one ton of coal under the assumed conditions. Of course, for the purposes of the calculation, it would have done equally well to have taken the conditions which obtain in the actual process, namely, a much higher E.M.F. and a correspondingly reduced current. Thus, if an E.M.F. of 100 volts had been selected, a corresponding current of 5,595 ampere-hours would have been taken, and while the copper deposited in each tank would have been $\frac{1}{179}$th of what it was in the first case, the E.M.F. would be sufficient to pass the current through $100 \times \frac{2}{3} = 150$ tanks instead of one.

To the cost of fuel necessary for producing the current had to be added that of labour, maintenance, stores, and that of refining copper matte, or rough copper, up to the standard pitch of purity, and also that of casting the anodes. The actual cost of producing a ton of pure electrolytic copper varied also somewhat with the design of the plant and the care that was spent in maintaining it. If the current was allowed to run to earth, if conductors of scant area and if dirty contacts were used, if the electrolyte was not maintained in proper condition, if very impure anodes were employed, and if the current passed through the tanks was so dense that a high electromotive was necessary, the cost of electro refining copper might easily be made ruinously expensive. But if the conditions were made and maintained favourable, as they could be with moderate care, the cost should not exceed from £3. 10s. to £4 per ton, and had in some instances worked out much lower. If due care was exercised in the selection of the brand of copper to be refined, this cost might easily be more than covered by the value of the gold and silver recovered from the sludge in the bottom of the tanks.

Treatment for Rendering the Deposited Copper Suitable for General Use.—The copper deposited in electrolytic refineries, though chemically pure, was of a crystalline character, and possessed but little cohesive strength. It was, therefore, in its deposited condition, quite unsuitable for the manufacture of goods, and was, in fact, only used for the manufacture of high-conductivity wire for electric purposes; and before being drawn into wire it had to be melted, cast into ingots, forged, rolled, and cut into strips. If the copper could be deposited in a tough, dense, and reguline condition at the same time that it was being refined, a great saving of expense would result.

The remainder of the Paper was devoted to the details of the Elmore process.

One of the great advantages secured by the use of the burnisher over and above the superior quality of the metal obtained is that the current density per square foot of kathode may be from three to four times that made use of in electro-refining, or in ordinary electro-plating. A current of 20 amperes per square foot is commonly made use of, and even 28 amperes have occasionally been employed with perfect success.

* Abstract of a Paper read before the Junior Engineering Society, January 15, 1892.

Electrolytic Gas Experiments.—An interesting experiment has been lately made by M. Chabry, of the Société de Biologie, with regard to the pressure which can be produced by electrolytic generation of gas in a closed space. While the highest pressure before realised in this way was 6,570lbs. to the square inch (447 atmospheres, Gassiot), M. Chabry has succeeded in getting as high as 12,000 or 18,000lbs. to the square inch; and the experiment was broken off merely because the manometer cracked (without explosion). The electrolysed liquid was a 25 per cent. soda solution. Both electrodes were of iron; one was the hollow sphere in which the gas was collected, the other an inner concentric tube. The current employed was 1½ amperes, and was very constant during the experiment, which was merely one preliminary to a research in which very high pressures were desired.

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ST. JAMES' AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).

The following report and accounts, being the first which we have had from a statutory electricity supply company covering a period of twelve months, and relating to a central station working under settled and generally favourable economic conditions, we have printed in greater detail than is our usual custom. The meeting is to be held at St. James's Hall Restaurant, Piccadilly, London, W., on Tuesday next, January 26th, at three p.m. :—

Report.

The Directors in submitting their annual report for 1891, with accounts as certified by the Company's auditors, congratulate the shareholders on the satisfactory progress made by the Company during the past year. Early in 1891 the capital of the Company was increased from £100,000 to £200,000 by special resolution of the shareholders creating 20,000 Seven per Cent. Preference Shares of £5 each. Of these shares 10,000 were issued to the shareholders at par, and fully subscribed for by them in March. The balance of 10,000 shares was issued in December last at 30s. per share premium, and duly allotted to the shareholders. This last issue of shares placed £15,000 at the disposal of the Directors as a capital reserve fund. The £15,000 has since been invested in Two and a-Half per Cent. Annuities, and is shown in the accounts annexed hereto.

The attention of the Directors has been largely directed during the year to the purchase of land for, and the erection of, a northern station. Owing to the congested condition of the parish and the extreme scarcity of available ground this proved to be a difficult matter. The Directors, however, are pleased to be able to report that they have secured a suitable freehold site in Carnaby-street, Regent-street, and have entered into a contract for the erection of the building on designs prepared by Mr. C. Stanley Peach, F.R.I.B.A. A considerable portion of the machinery and boilers required for this station have already been constructed, and it is hoped that during the summer of this year the station will be finished and in working order. There are certain compulsory mains which have to be laid in the parish before August next. These, with other mains which the Board deem necessary to complete the system, will be proceeded with without loss of time, and there seems every reasonable probability of the whole of the work being completed without any further capital being required.

It may be of interest to the shareholders to know that the two stations will be connected by a grand trunk main, about half of which is already completed and laid. This will be a means of enabling the northern station to support the southern in case of necessity, and *vice versâ*.

The system adopted by the Company has worked thoroughly well during the whole of the year, and the Directors are satisfied that it is the best that could be selected having regard to present knowledge. The experience gained at the Company's works enables the Company's officials to make improvements from time to time, and no precaution is neglected to maintain the excellent results hitherto obtained.

The net earnings of the Company during the past year have amounted to £10,395. 12s. 5d. Of this sum, £3,610. 6s. 4d. was distributed in July last in payment of an interim dividend at the rate of 7 per cent. per annum for the half-year ended June 30, 1891, on the ordinary shares, and on the instalments paid on the first issue of preference shares. The balance of £6,785. 6s. 1d., added to £315. 12s. 9d. (the undivided profit from last year's account), leaves £7,100. 18s. 10d. now to be dealt with.

The Directors propose to divide this amount as follows, viz. : –

(*a*) By payment of a dividend at the rate of 7 per cent. per annum calculated on the instalments paid on the first issue of 10,000 preference shares for the second half of the year	£1,333 6 8	
(*b*) By payment of a dividend at the rate of 10 per cent. per annum for the second half-year on the ordinary shares, making, with the interim dividend paid in July last, a total distribution of 8½ per cent. for the year	4,670 0 0	
(*c*) By paying a dividend of £10 15s. per share on the founders' shares	1,075 0 0	
(*d*) Amount to be carried forward to ordinary shareholders' undivided profit account	6 2 6	
(*e*) Amount to be carried forward to founders' undivided profit account	16 9 8	
	£7,100 18 10	

The Directors have carried £1,000 to "Redemption Account" to commence a fund, to accumulate by annual additions, to represent loss of capital at the expiration of the term covered by the Provisional Order. The Directors are advised that the amounts provided in the accounts for depreciation are sufficient and ample for all purposes.

Two of the Directors, namely, Messrs. Egerton H. Clarke and H. Woodburn Kirby, retire under Clause 79 of the Articles of Association, and, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., also retire, and, being eligible, offer themselves for re-election.

Dr. *Capital Account for the year ended December 31, 1891.*

—	Expenditure up to Dec. 31, 1890.	Expended during the year.	Total expenditure up to Dec. 31 1891.
To	£ s. d.	£ s. d.	£ s. d.
Land (including law charges incidental to acquisition)	9,598 0 8	20,297 7 8	29,895 8 4
Buildings and paving	11,186 0 7	1,958 14 11	13,144 15 6
Machinery and plant	27,905 6 4	12,056 11 11	39,961 18 3
Accumulators	1,596 5 5	23 7 11	1,619 13 4
Mains, including cost of laying	28,631 11 1	9,531 10 7	38,163 1 8
Meters fixed on installations	1,578 19 0	1,271 18 2	2,850 17 2
Switches do. do.	700 0 3	544 2 0	1,244 2 3
Stores and labour used on do.	1,172 19 7	883 9 1	2,056 8 8
Electrical instruments, &c.	256 0 6	106 9 1	362 9 7
Patent rights	—	30 0 0	30 0 0
Cost of licence and Provisional Order	705 10 2	—	705 10 2
Sinking Artesian well	668 2 6	286 17 6	955 0 0
Office and other furniture and fittings	510 1 5	207 3 2	717 4 7
Compensation	392 13 10	—	392 13 10
Expenses connected with Board of Trade Inquiry	152 8 7	—	152 8 7
Preliminary expenses	920 1 11	105 10 0	1,025 11 11
Expenses of debenture issue	275 7 4	—	275 7 4
Law and Parliamentary expenses	539 19 6	28 1 9	568 1 3
Management, general expenses, and interest to December 31, 1889, less receipts	5,337 9 6	—	5,337 9 6
	92,126 18 2	47,331 3 9	139,458 1 11
Balance of capital account	—	—	15,541 18 1
			£155,000 0 0

Cr.

—	Receipts up to Dec. 31, 1890.	Received during the year.	Total receipts to Dec. 31, 1891.
By—	£ s. d.	£ s. d.	£ s. d.
Ordinary shares, 18,680 of £5 each	44,880 0 0	48,520 0 0	93,400 0 0
Preference shares, 10,000 of £5 each, fully paid	—	50,000 0 0	50,000 0 0
Preference shares, 10,000 of £5 each, 10s. paid	—	5,000 0 0	5,000 0 0
Founders' shares, 100 of £1	100 0 0	—	100 0 0
6 per Cent. Mortgage Debentures	50,000 0 0	—	—
Less converted into ordinary shares during 1891	43,500 0 0	—	6,500 0 0
			£155,000 0 0

Dr. *Revenue Account for the year ended December 31, 1891.*

A.—*To Generation and Distribution of Electricity.*

			£ s. d.
To Coals and other fuel, including dues, carriage, &c.		4,668 8 3	
„ Oil, waste, water and engine room stores		771 17 2	
„ Salaries of engineers and officers		609 12 6	
„ Wages at generating and distributing station		2,835 2 0	
„ Repairs, maintenance and renewals, as follows :—			
1. Buildings	£562 8 2		
2. Engine and boilers	669 3 8		
3. Dynamos	186 14 2		
4. Other machinery, instruments and tools	145 0 6		
5. Accumulators	4 13 10		
6. Lamps (at station)	134 4 1		
		1,702 4 5	
„ Repairs, maintenance and renewals of mains		527 15 6	
„ Miscellaneous expenses		72 13 4	
			11,187 13 2

B.—*To Rents, Rates, and Taxes.*

To Rents payable		419 2 9	
„ Rates and taxes		360 14 10	
			779 17 7

C.—*To Management Expenses.*

To Directors' remuneration		1,155 1 5	
„ Salaries of general manager and secretary, engineer, clerks, &c.		1,816 0 3	
„ Stationary, printing and advertising		353 6 0	
„ General establishment charges		247 2 5	
„ Auditors of Company		52 10 0	
			3,624 0 1
Carried forward			£15,591 10 10

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Brought forward			£15,591 10 10
D.—To Law and Parliamentary Charges.			
To Law expenses			658 14 7
E.—To Special Charges.			
To Insurance	158 13 8		
„ Brokerage on shares	14 1 0		
			172 14 8
F.—To Depreciation.			
To Depreciation on buildings	285 8 10		
„ ditto plant, machinery, &c.	3,727 19 1		
			4,013 7 11
G.—To Redemption Fund.			
To Provision for recoupment of capital expenditure			1,000 0 0
			21,336 8 0
„ Balance carrried to net revenue account			10,562 6 10
			£31,898 14 10

Cr.

	£ s. d.
By Sale of current, after deducting provision for bad and doubtful debts	30,934 14 4
„ Sale of current under contracts	215 3 6
„ Rental of meters on consumers' premises	362 2 11
„ Rents receivable	100 0 0
„ Transfer fees	117 9 6
„ Discounts on purchases	134 14 9
„ Sale of old materials, stores, &c.	34 9 10
	£31,898 14 10

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January* 8, 1892.

The Edison General Electric Company.—The topic of the hour is the coming annual meeting of the Edison General Electric Company. It was to have been held to-day, but, for some reason as yet not made public, has been postponed to an unknown date. The facts are kept hidden in the closest manner, so that very few, even among those high in the councils of the Edison Company, know what the delay means. Meanwhile there are as many opinions as men about the business that will be transacted at this meeting. It may be trivial, dealing only with minor matters, but the general opinion is that the results will be of far-reaching importance. It is understood that the present management is likely to go out, in part at least, probably almost as a whole. Whether in going Mr. Villard, the present president of the Company, will take Mr. Edison with him or not is a question as yet unsolved. Certain it is that Drexel, Morgan and Co. hold the key to the situation, probably controlling a majority of all the stock, in spite of Mr. Edison's large personal interest. If the new management promised to be inimical to Edison he might either make peace with them or leave with Villard; in the latter event, it is hinted that a new electrical organisation would take the field, based, perhaps, on the old North American Company, together with some others that Villard has been organising. It may be that the present delay in the annual meeting is due to interests connected with this organisation. Nothing has as yet leaked out, as is shown by the stability of the North-American stock and also of the Edison stock itself.

The Westinghouse Company.—The reorganisation of the Westinghouse Company seems to have been attended with considerable success, and that Company is apparently now engaged in a still hunt for business that is proving reasonably successful. Very little is said, but a considerable amount of work is done at the factory.

A Postal Telegraph System.—The annual report of the Postmaster-General recently published contains a strong plea for a postal telegraph system, a subject that is likely to be largely before the public during the next few years. It is earnestly desired by the Post Office authorities, but is looked at askance by the public in general. The Postmaster-General also suggests, what is much more practicable, a moderate use of a public telephone service by the Post Office department.

The Chicago Exhibition.—Work in connection with the Electric Section of the World's Fair is steadily progressing. The official situation there is particularly unfortunate, as the chief architect, Mr. Burnham, is now at loggerheads with the head of every department and with the Director-General. It is becoming a question whether the Exhibition will be Burnham's Fair or the World's Columbian Exposition. Mr. Barrett, of the Electrical Section, is doing everything in his power to put his department into good working order; but has encountered considerable opposition from the architect, who desires, for reasons best known to himself, to control the lighting problem personally.

The Proposed Electrical Congress.—The unfortunate difficulty between Prof. Elisha Gray, who was placed by the Government at the head of the Electrical Congress and the American Institute of Electrical Engineers, is apparently now at an end; Prof. Gray having seen the advisability of acceding to the propositions of the Institute.

Electric Traction in Brooklyn.—Something of a sensation has been created by the Mayor of Brooklyn vetoing the ordinance granted by the aldermen for the change in motive power from horses to electricity. It is probable that the hindrance will be but temporary.

CORRESPONDENCE.

OVERHEAD WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the paragraph which appears in your issue of the 8th inst., and to the letter from the Board of Trade on this subject which you publish, the fact that the memorial to the Board of Trade has been signed by a very large number of representative men in the industry points to the general feeling of anxiety which was felt that the Board of Trade intended to disallow all overhead wires for electric lighting. It will, therefore, no doubt be a matter of satisfaction to all who are interested in the electrical industry that the Board of Trade now state officially that "they have not laid down any absolute rule that overhead wires shall in no case be employed," although their statement "that they will be prepared to authorise the use of such wires in any case in which they are satisfied that the interests of the public require it" cannot be regarded as altogether a satisfactory position in which to leave the question.

The Memorial above referred to shows that electrical contractors have no wish to erect overhead wires otherwise than in accordance with regulations which the Board of Trade may prescribe in the interests of the public; and what the industry was afraid of was that the Board of Trade had laid down the principle that no overhead wires for electric lighting purposes should be used as a permanent arrangement. That such a misapprehension has arisen is perhaps excusable after the receipt by Messrs. Crompton and Co. of the letter from the Board of Trade, of which I enclose a copy.—I am, Sir, &c.,

St. George's Square, S.W. S. FLOOD PAGE.

[COPY.]

Ass'tant Secretary, Board of Trade,
(Railway Department), London, S.W.

CHELMSFORD ELECTRIC LIGHTING LICENSE, 1890.

SIR: With reference to your letter of the 23th ultimo, containing a description of the system of supply proposed to be used for the purposes of the above-mentioned License, I am directed by the Board of Trade to inform you that they are unable to approve of any system in which overhead wires are used as a permanent arrangement, and that they would not be prepared to give even a temporary approval to a system in which such wires were used unless they were erected in strict accordance with the regulations of this department.—I am, Sir, your obedient servant,

R. D. HERRINGTON.

DOES ELECTRICITY EXIST?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As I have always taught that electricity has no real existence as a substance, or quasi-material fluid, or ether, of course your expressed disposition to that view is welcome; but still it may be questioned whether the "coulomb" is likely to

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disappear from our growing list of units. To use your "American thinker's" phrase, though electricity is not an "is-ness possessed of somewhat-ness," it may be that it is a somewhat-ness manifested by an is-ness. That is my own view, and it follows that the is-ness will be a "quantity" involving the coulomb conception; while the somewhat-ness is represented by "potential" or stress force.

The misfortune is that the coulomb is not a quantity at all in any ordinary sense; it is itself a measure of energy in reality, as its very dimensions show; $L^{\frac{3}{2}} M^{\frac{1}{2}} T^{-1}$ or $M^{\frac{1}{2}} L^{\frac{1}{2}}$ do not represent an analogue of mass or quantity, yet the exact analogue does exist, obscured by our conventional system. The unit of electric quantity—the is-ness—is simply the unit of chemical structure of matter, the equivalent; while the "somewhat-ness" is manifested by it in the form of energy, which I christened "voltance" some while ago in these pages, the chemical form of potential.

Now, I want to question a scientific dogma, viz., that "heat *is* energy," as you say in your Note, p. 214. There has always been in my mind a dissatisfaction with the discrepancy in our ideas about heat and electricity, and I have just traced out the cause in the complete acceptance of the neat phrase, "Heat is a mode of motion," and the overlooking the fact that it is a motion of a "thing;" we treat it as a mere "somewhat-ness," and forget the "is-ness." As a simple natural truth, heat, electricity, and mechanical motion (such as the fall of a weight) have analogies (identities in principle), far more complete than Dr. Gerald Molloy sets out, p. 236.

In all we have exactly the same two elements: A, a material quantity; B, an energy exerted. In electricity we have for A the *equivalent of matter*, and for B the fall of potential, the expenditure of energy. In heat we have the *atom of matter* for A, and the fall of temperature, the transfer of energy, for B. In hydraulics we have the mere *mass of matter*, say a pound as unit for A, and, again, the loss of pressure, energy expended, for B. I may here refer to the suggestion that a "pound" is a measure of energy; as in so many cases that is a truth which hides a fallacy. When we look beyond the surface we must see that we have no measure whatever of anything except energy. Mass itself is only known as energy. We call it the measure of the absolute quantity of matter, but all we know about that is that it exercises a measurable force upon other masses. An atom of hydrogen is a mass of 1, an atom of silver is a mass of 108. Are these measures of "quantity of matter?" Who can say? All we know is that as regards the force of gravitation the atoms manifest these forces; but then as regards electricity they are equal, and as regards heat they are equal. Again, 108 of silver and 28 of iron are equivalent as electrical or chemical masses, but not as regards heat, which takes 56 of iron to equal 108 of silver.

Mr. Molloy, asking for the relations, says "the energy of the electric current resembles the energy of falling water, but does not resemble the energy of heat;" and so everyone would probably say, and say wrongly, as I probably should have said myself till lately. The reason of the error is that heat is readily treated mathematically and mechanically; it is only the chemist who has anything at all to do (and he very little more than as a fact of little practical influence) with the relation of heat to the atomic structures of matter. Therefore it is that in the mathematical and mechanical treatment, alike of heat, which can be treated wholly apart from its links to material structure, and of electricity, which can be so divorced, except in the study of electrolysis, the fundamental fact, the relation of energy to matter, is wholly overlooked, and mere symbols and conventions have shut our eyes to the plain teachings of nature.—Yours, &c., JOHN T. SPRAGUE.

$d\,M/d\,x$.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Myself, and I am sure many other non-mathematical readers, will feel obliged to Mr. Searle if he kindly shows how the numerical values of $d\,M/d\,x$, given in the table on page 251 of your issue of the 8th inst., are calculated.—Yours, &c.,

K. W. R.

PARSONS' STEAM TURBINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We were interested in Prof. Ewing's report on the above. Some years ago we put up a large resistance (40 ohms) of *very* open iron wire spirals, for the purpose of testing alternating-current dynamos. From careful experiments we found that the current passing, as measured by a Siemens electro-dynamometer, multiplied by the E.M.F. measured by a Cardew voltmeter, did not represent the electrical horse-power being given out. Indicator diagrams taken from engine showed that less horse-power was indicated in the cylinders than that in the external circuit, calculated as above.—Yours, &c.,

THE ELECTRIC CONSTRUCTION CORPORATION, LIMITED.
T. PARKER,
January 19, 1892. Chief Engineer and Head Manager.

STEAM-ENGINE ECONOMY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to the letter of Messrs. Willans and Robinson in your columns of last week, we would wish to state that it was not our intention to challenge record runs, and, therefore, in the tests made by Prof. Ewing no arrangements were made conducive to exceptionally high economies: these are the use of very high boiler pressure, and a separator or other means for obtaining very dry steam.

In the present tests the pressure at the engine never exceeded 75lb., and the steam was not dried.

It would be interesting to know with what steam pressure and engine Mr. Willans obtained the results stated by him at the meeting of the Institute of Civil Engineers last spring, for we are unable to find any mention of these two important factors in the proceedings of the Institute.—Yours, &c.,

C. A. PARSONS AND CO.

Heaton Works, Newcastle on-Tyne.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS INVITED.—The Public Lighting Committee of Waterford invite tenders for the public lighting of part of the city at present lighted by electricity, and also in the alternative, for the public lighting of the entire city, either by gas or electricity, for periods of two, five, or ten years, from September 1, 1892. All information can be obtained at the office of Mr. M. J. Fleming, borough surveyor, The Mall, Waterford; and tenders are to be sent to Mr. Joseph W. Howard, town clerk, by February 1st. Further particulars appear in our advertisement columns.

——— Tenders are invited for the lighting by electricity of the rooms which formerly constituted the kitchens at the Castle Museum, Nottingham, and should be sent to Mr. Geo. Johnson, town clerk.

TENDERS RECEIVED.—At the meeting of the Chiswick Local Board on Wednesday, the following tenders for the erection and maintenance of fire alarm posts, calls, &c, were opened:—Roxburgh and Co., with telephones, £330, without £290; Messrs. Blenheim and Co., with, £379; Messrs. Spagnoletti and Crookes, with, £415, without, £365; Mr. F. E. Stuart, with, £438. 17s., without, £368. 17s.; and the Home Telephone Company, with, £300, without, £265. It was decided that Dr. Diplock, captain of the fire brigade, should consult with the surveyor on the tenders, and report to the Board.

SIMPLEX ELECTRICAL SYNDICATE, LIMITED (IN LIQUIDATION).—A meeting of the shareholders is to be held at 4, Hercules-passage, Threadneedle-street, London, E.C., on February 16th, at 3, to receive an account of the winding-up.

MESSRS. LAING, WHARTON AND DOWN.—This firm notify us that the recent removal of the offices of the Laing, Wharton and Down

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Construction Syndicate to 38, Parliament-street, Westminster, London, S.W., which has taken place owing to the increase of both businesses, in no way alters the address of the old established firm of Messrs. Laing, Wharton and Down, whose address is still 82A, New Bond-street, London, W., with branch and City offices at 17, Gracechurch-street, London, E.C.

THE PAST YEAR'S WORK.—Messrs. Priestman Brothers (Limited) report that successful progress has been made by the firm during 1891 in the introduction of the Priestman oil engine. The firm inform us that hundreds of these engines are now in daily use, and that during the past year, amongst many others, orders have been received from the New South Wales, Spanish, and Norwegian Governments, the Elder Brethren of the Trinity Honse, the Northern Lighthouse Board, Messrs. Bolckow, Vaughan, and Co., Palmer's Shipbuilding and Iron Company (Limited), Bell Brothers (Limited), and other public bodies and companies, both at home and abroad; and in addition to these important orders, several repeats have been received, included amongst which are the Norwegian Government for two 7 H.P. engines, the Northern Lighthouse Board for six engines, Messrs. Bell Brothers for five engines, and Volkart and Co. for three engines. The marine type of the Priestman oil engine has now been perfected, and orders have already been received for these engines. Amongst the uses to which this engine has been adopted during the past year may be mentioned electric lighting, hauling, pumping, &c. From the above it will be seen that the Priestman oil engine has demonstrated its usefulness, and it may fairly be said to be in competition with steam and gas as a motor.

——— We have received from the Mutual Telephone Company some particulars of the progress made during the past year, the chief point of interest in which is the fact that the Company has now (January, 1892) between 900 and 1,000 subscribers on their system. Three call boxes on the Company's boards at the Royal Exchange, Manchester, will be opened at the end of January. Subscribers to the Company's exchanges will be entitled to use these boards for the purpose of speaking within a radius of six miles without charge on producing evidence of identification. An exchange is to be opened in Bolton shortly, and trunk-line communication on the metallic-circuit system is to be established with Manchester, and it is also contemplated to open an exchange at Farnworth.

ST. PETERSBURG ELECTRICAL EXHIBITION.—On January 14th a series of trials took place of the motors, &c., exhibited at the Electrical Exhibition at St. Petersburg, which, we learn, were a great success. A committee has been organised consisting of engineers, technological specialists, and officers, for the purpose of explaining and demonstrating the use of the chief exhibits to the Russian public. St. Petersburg has been connected with Gatchino, the Emperor's summer residence, by telephone, as has also Pskov, distant about 170 miles. Much interest is taken in the Exhibition, which promises to be very successful.

TOOL BOXES FOR ELECTIC LIGHT FITTERS.—These tool boxes are made by Messrs. Kücke and Co., of Elberfeld, and are sold in this country by Messrs. O. Berend and Co. The box measures externally about 30in. × 19½in. × 15½in. high; it is made of tough wood, fitted with strong handles, and strengthened at the edges all round with strong metal mounts. To take the strain off the lock two hasps are provided, with castors let into the bottom. The tools are held in place partly by leather loops and partly by steel spring-hooks (which can be folded back), and are arranged in the lid and at the sides of the box, as well as on six moveable trays, folding down horizontally, the arrangement being such as to allow of inspecting at a glance the whole contents of the box, and enable the fitter to place every tool in such a position as to enable him to place his hand on any desired tool in an instant, and to remove it readily and without any obstruction. The central compartment, which, by means of a false bottom made to lift out, is divided into two halves, serves in its upper part for storing the fitter's working clothes, while the lower division contains a tackle of pulleys and various wire clamps. A partition at the back, which can be pulled out after the removal of the false bottom, gives access to a small shelf-rack containing soldering utensils, and includes a soldering lamp, spirit bottle, jar for acid, and sal-ammoniac and boxes for binding material. The box, with all contents complete, weighs about 120lb., and is arranged for fitters working independently. They are also made for use by assistant fitters.

ALMANACKS, &c.—We have received from the Commercial Cable Company a neatly printed date remembrancer for 1892.

MESSRS. LIRONI, BOWMAN AND CO.—We are asked to state that Mr. V. G. Lironi (late of Messrs. Woodhouse and Rawson and the Elieson Electric Company) and Mr. J. J. Bowman (of Newport, Mon.) have taken over the business until lately carried on by Messrs. Hollington Bros., at the Bow Electric Works, Arnold-road, Bow, E.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

December 21, 1691.

22,316. J. D. F. ANDREWS. London. Improvements in electrical distribution and transformers therefor.

22,326. H. L. CALLENDER. London. Improvements in Wheatstone bridge apparatus, and in the adaption of the same to the measurement of temperatures, electric, potential, and current.

22,339. N. WLADIMIROFF. London. Improvements in primary and secondary batteries.

December 22, 1891.

22,354. G. E. PAINTER. London. Improvements in electric switches.

22,360. J. JACKSON. London. An arrangement for securing good contact in electric switches, and for avoiding dead stops in their action.

22,375. A. BIDRON and W. I. G. LEWIS. London. Improvements in shades for gas, electric, and other lights, and in the mode of manufacturing the same.

22,376. C. S. SNELL and WOODHOUSE AND RAWSON UNITED (LIMITED). London. Improvements in switches for electrical purposes.

22,404. H. W. BOWDEN, A. GAY, and R. HAMMOND. London. Improvements in the coupling of electric mains.

December 23, 1891.

22,473. C. DREVS. London. Improvements in electrical heating apparatus.

22,478. I. A. TIMMIS. London. Improvements in the construction and working of electric accumulators.

22,482. H. H. LAKE. London. Improvements in voltaic cells. (C. Weston, United States.)

December 24, 1891.

22,5?7. R. A. FRASER and G. F. R. KELSON. Liverpool. Improvements in supports for telephone receiving instruments.

22,533. T. JENNER. London. Combined portable electric lamp and battery, which may also be applied to act as a burglar alarm.

22,554. H. H. LEIGH London. Improvements in batteries and accumulators. (J. F. Weyde and F. Class, Austria, and J. Elsner, France.)

22,555. A. BERNSTEIN. London. Improvements in dynamo-electric machines.

December 28, 1891.

22,575. R. KENNEDY. Glasgow. Improvements in dynamo-electric machines.

22,576. R. KENNEDY. Glasgow. Improvements in alternating-current generators and electro-motors.

22,593. F. H. BROWN and W. F. MELBOURNE. Haverfordwest. A combined telephone and telegraph.

22,605. C. F. PARKINSON. Lancaster. Improvements in conduits for electrical conductors particularly suitable for electrical traction.

22,609. R. BALLARD. London. Improvements in incandescent electric lamps.

COMPANIES' MEETINGS & REPORTS.

The Eastern Telegraph Company (Limited).

The thirty-ninth half-yearly ordinary general meeting was held on Thursday, January 14, 1892, at Winchester House, 50, Old Broad-street, London, E.C.; Sir John Pender, K.C.M.G., in the chair.

The SECRETARY (Mr. George Draper) having read the notice convening the meeting, and the minutes of the last meeting, which were confirmed,

The CHAIRMAN said: Gentlemen, I presume that you will take the report as read. You have had it in your hands for some days. Before going into the business to-day, however, I think you will all agree with me that we shall feel the deepest and warmest sympathy with the Royal Family in connection with the dark shadow which has fallen upon them. Probably on no other occasion has news passed so rapidly over this vast Empire as the news of the death of the Prince who has just passed away. The Company in which we are so much interested has been the medium of conveying the sad information to every civilised portion of the world, and thus, I may say, it has been known by them almost within the same space of time as we knew it here. I am sure that the sympathy throughout the world will be as universal and deep as is the sympathy which exists in the more immediate surroundings of the Queen and the Royal Family. We tender to them all our deepest and warmest sympathy. I will now refer to the accounts, and I shall then give every gentleman the opportunity of putting any questions he may desire to put before I submit the resolution to the meeting. Our message receipts for the half-year under review amounted to £321,135, as against, in the corresponding period of last year, £318,728, an increase of £2,407. Dividends from our investments in other com-

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panies were £33,399, as against £33,455, a decrease of £56. Interest and transfer fees show a falling off of £285. Our gross revenue was £354,939, as against £352.873, an increase of £2,066. The shareholders will remember that on July 1st a considerable reduction of rates came into operation on inter-European telegrams. This reduction, I am glad to say, has been nearly recouped, showing that there is considerable vitality in our business; and wherever there are Europeans using the telegraph that vitality is more marked. Included in the present accounts is the loss on five months' traffic occasioned by the reduction of tariff with Australia. That great reduction to Australia is still going forward, and we have only had about eight months' experience of it. At the end of twelve months, when I next meet you, I think I shall be able to make a very satisfactory report to you. We have already made good smaller losses by increased traffics in other directions; and on the whole we are very well satisfied with the result of the conference that was held twelve months ago. We can only deal with the actual condition of things up to the date when our accounts are made up; but with regard to Australia we are hopeful that a considerable portion of the loss shown at the end of September will be made up by increased receipts before the end of the current financial year. I do not think it desirable to give any figures at this moment, but it must be satisfactory to the shareholders to know that, in spite of the important reductions in the tariff between European countries and with Australia, increased traffic with other countries, where we have not been obliged to reduce our tariffs—notably with South America—enabled us not only to cover the loss resulting from the reductions, but to show a small increase of revenue. The total expenses for the half-year ended September 30, 1891, amounted to £97,130, as against £91,723, or an increase of £5,407. Included in this half-year's figures, however, is the item, for special repairs for buildings at Alexandria and Port Said, £2,450; and the amount carried to the maintenance ships' reserve fund is £4,000, against only £2.500 in the corresponding period. Several of the other items show an increase, while others exhibit a decrease. The details are as follow:—General expenses in London, £9,412, against £8,502, or an increase of £910, the principal being rent, office expenses, and repairs and renewals of furniture, necessitated by the additional accommodation required to meet the demands of the service. Working expenses at stations amounted to £73,097, against £68,435, an increase of £4,662. The additional expenditure under the heading of salaries and wages, rent, fuel, and light, &c., was incurred last half-year, and was fully explained at our meeting six months ago, the necessary increase in the number and additional pay and allowance granted to some of our foreign staff being the cause. The use of patents amounted to £755, against £1,416, a decrease of £661. This is a permanent reduction, some of the patents for which we have been paying royalties for some years having expired. The expenses attending repairs and renewals of cables amounted to £47,048, against £31,478, or an increase of £15,570. In the corresponding period of 1890 the amount chargeable for repairs to cables was exceptionally light, owing to the large credits derived from other companies for the hire our ships for cable repairing purposes. It will be seen from Abstract C, that we have laid in 129 knots of new cable, the cost of which is included in this half-year's figures. The result of this half-year's working is that, although we have a small increase in the gross revenue, we carry forward £57,509, against £78,195 in the corresponding period of 1890, or a decrease of £20,686; but it must be remembered that the half-year to September, 1890, was, as regards ships' expenditure, an exceptionally favourable one. I would call your attention to the important fact that in spite of the large addition which we have made to our cable system during the last six years, the capital expenditure under this head has remained, since 1885, at practically the same figure, notwithstanding that we have laid over 7,000 miles of new cable during that period. This half-year we have applied from the reserve fund the sum of £105,110 in reduction of capital expenditure, and the total amount charged against reserve and revenue accounts to September 30th last is £1,101,463, the balance remaining in our general and other reserve funds being £508,509. I think, gentlemen, you will consider this a very satisfactory position to be in. About eleven years ago the shareholders were good enough to sanction what we called then an insurance fund. A few months ago, when I was addressing the Eastern Extension Company, I drew the attention of the shareholders to an amended system which we are desirous of introducing, and which at the presnt time is in the hands of the actuaries. Telegraphing is a very peculiar business. Probably the youths are, so far as their fingers are concerned, more expert operators than when they become older men. I do not mean to say that their heads are as good, but their fingers are better when they are young; and if we are to get good people around us, we must hold out some benefit to them as an inducement which they will be able to enjoy at the end of a long and arduous life. We think that by encouraging thrift, economy, and generous action on their own part, we should meet that so far by adding to the sum contributed by them, so as to enable each man, after attaining the age of 50 or 60, as we may determine, to retire from the service with a competency. We must bear in mind that our business is not an ordinary business. It is a business in which great confidence has to be placed in the men who work it, and we must have about us a class rather above the ordinary—or rather, I should say, confidential men, well-educated, well connected men—men who would have some little feeling of respect for their names and position; and to secure these men, we require to hold out to them a future rather better than we have been able to hold out to them in the past (applause). We have also to bear in mind that a great deal of our work is conducted in distant countries, in tropical climates, and never in very pleasant places, because we have always to have the bulk of our staff near to where our cable is landed. The consequence is that they live a quiet and lonely life, and not a life which, I think, tends very much to health or to life itself; but still, we always get men ready and willing to go out, though we think it is very advisable that we should be just and generous with the young fellows who enter our service, and to let them feel that we are in touch with them in the course of their working life (cheers). I am glad to hear you signify your approval of that course. I am not going into the details of this scheme to-day. We are working it out most carefully. We have it now before the actuaries, and the whole thing is worked out in such a way that when I put it before you I have no doubt that you will agree that it is fair and just both on the part of the shareholders who constitute the Company and also on the part of the clerks themselves. I am not going to trouble you long to-day. I was looking over the speech which I made six months ago to you, and I think were I to repeat that to-day it would be out of place. I am not going further into details than to say this—that your business is thriving. It is also realising what I have always told you, that every day we live telegraphing becomes a greater necessity. The world could not now move without the system of telegraphy as it at present exists; and as the world grows, so must telegraphy. We are at the head of it, too; our arrangements and appliances are such that we are at the head of everything connected with telegraphy. We have some cables still to duplicate. We have some money yet to spend, but we take care before we spend the money to see where it will come from. We are most desirous, above all things, not to overburden our capital, if we are to keep up a good, steady dividend, such as we are now paying; and when you take into consideration the reduced value of money, and you see that we still maintain our high rate of dividend, I think you may be satisfied that the investment you have made is a good and sound one; and it is believed to be a sound investment by the whole commercial community of this and other places. In spite of the convulsions which have shaken the proudest houses to their foundations, and in spite of the great depression that has been prevailing in commerce, you see the shares of the Eastern and of the Eastern Extension Companies standing rather higher to day than they have done at any former period of their existence. I think I cannot offer you a better evidence of the belief that is held in our property. More than that, you find that our Four per Cent. Debentures are at 108 to 109, which is a further evidence that your property ranks in the forefront among first-class investments. I think I have said sufficient to show you that we are going on pleasantly and satisfactorily. We are going on beneficially for you, and we are satisfying the public that we are anxious to conduct our working in such a manner as to meet with their approval. I hope that as shareholders of this Company you will feel as pleased with the result attained as your Directors do in having contributed towards it (cheers). With these remarks I beg to move—

"That the report and accounts of the Directors to September 30, 1891, submitted to this meeting, be and the same are hereby received and adopted."

The VICE-CHAIRMAN (The Most Hon. the Marquis of Tweeddale): I beg to second the resolution.

The CHAIRMAN: If any gentleman has any question to ask me I shall be very pleased to answer him; but if not I shall put the resolution.

Mr. JOHN NEWTON: I do not think that the important statement which you have made to the meeting should be allowed to pass without some remarks from this side of the table (hear, hear). I think that I am one of the oldest shareholders in the Company, and on former occasions I have criticised very freely the position of the Company. I am, however, satisfied at seeing the prosperity which we now enjoy. Our shares were once only half their present price, and I am sure that those who then held them and who have held them since must be immensely gratified at seeing that the Directors are now going to recognise the services of those to whom we are so much indebted for the improvement in our position, greatly as we are indebted to our Directors. The scheme which you have announced is one which, from what you have said, will greatly benefit the new members of the staff; but I hope you will not forget the older members, who cannot now begin to make any higher payments to this fund (applause). Let those who have served us in the past, in our period of adversity, when I do not think that the remuneration was as much as it should have been, have the full benefit now of what you propose. I have a great deal of pleasure in supporting what you have said.

Mr. WEIR: The last speaker has urged that the claims of the older servants of the Company should not be overlooked; but I feel quite sure that they are in good hands while they are in the hands of our Chairman and his colleagues. I must confess to having had some misgivings when the reduction in the tariff to Australia was submitted to, but I am gratified to find, from what you have said, that matters in this respect are progressing satisfactorily. I should like to make an observation as to the wisdom and the capacity of our Board. Our Chairman has said that during the last three years, while great commercial and financial houses have been shaken to their foundations, the securities of this Company have resulted in a profit of some £16,000, and that in the past half-year. That shows that the securities which we hold are of the highest order. I feel that the Chairman and his colleagues deserve our best thanks for having shown so much prudence and care in the investments which they have made on behalf of the Company.

Dr. WALLER: May I be allowed to say a word? It is most satisfactory to me to find such unanimous and cordial approbation of what the Board is about to do. The gentleman who first addressed the meeting says he is an old shareholder. I am sure that I am an older man than he is, and I believe that I am quite as old a shareholder; but I am what he is not, and what I am glad to see he is—that is, a convert. I am glad to see that a gentleman who was not always cordially disposed towards you is so to-day. That is most satisfactory, and I hope that as this change has taken place it will continue until he is one of the most ardent supporters of this, one of the greatest companies in the world. You have so eloquently indicated all the benefits that will result from the philanthropic scheme to which you have referred, that nothing remains to us at this meeting to say on the matter; but I may say that I am glad to find that a Company like this can be philanthropic. You never, perhaps, did a wiser thing than when you tried to encourage a class of men to our service who will be

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what you say yourself—faithful and confidential. I believe that a better thing could not have been done (applause). Everything that you say is well said, and nothing could have been better said than what you have said on this subject, and it leaves the shareholders little, or comparatively little to say.

Mr. BAIN: May I ask if all our cables are in perfect working order? On several occasions we have had interruptions at certain places. There is no allusion in the report to this subject, and may I ask you, therefore, if you will refer to it?

Mr. WHISH: Am I right in assuming that we do the whole of our maintenance and repairing work ourselves, and, if so, whether the conclusion has been arrived at that we can do so more economically than by entrusting the work to companies who make such work their special object?

The CHAIRMAN: In reply to the questions which have been put to me I may state, first of all, that we are not forgetting our old *employés*. We have a good many old and faithful servants about us, and we are carrying them, more or less, along with us in what we are doing. I may say we are taking the deepest interest in our young men, but there may be two or three special cases in regard to our old *employés*. I can assure you that we shall never desert our old and faithful servants. There was another question put to me, Whether all our cables are in working order? To that I would say that they are above the average. We are rarely, however, without a broken cable, but having adopted the system of duplicate cables wherever we have the power to do so, the public know little about these breaks now. We had a very important break the other day in the South African cable, which, though not the Company's, is practically owned by this Company; and had we not had our ships in order to attend to this break at once, I think it would probably have been some time before the repair was effected. It is one of the most remarkable instances of the promptitude with which our work is done that that cable was broken and repaired within five days. Had it been in others' hands, or not within our control, it would probably have taken two months to repair. Another question that was asked me was whether we repair our own cables? Yes, we do, and some of other people's also. We never allow our ships to lie idle if we can help it, and we never lose an opportunity of making them earn a nimble penny, because we have always a place where to put it. During the present half-year we earned outside our own Company, by our ships, £15,000, and in the corresponding half-year of 1890, we earned in a similar way, £22,000. You will therefore see that while we are cable workers we are also cable repairers, and not strictly for ourselves, but whenever we can earn a penny from anybody we do so. We think we do this work cheaper than we could have it done for us by others. These are all the questions, I think, that I have to answer, and I dare say you feel satisfied at what I have said. I will now put the resolution. Those in favour of it will please hold up their hands. To the contrary. Carried unanimously. The next resolution is—

"*That Sir A. J. Leppoc Cappel, K.C.I.E., who now retires, be and he is hereby re-elected a Director of the Company.*"

The MANAGING DIRECTOR: I have much pleasure in seconding that.

The CHAIRMAN put the motion to the meeting in the usual way, and, having declared it carried, said: The next resolution is—

"*That Lord Sackville A. Cecil, who now retires, be and he is hereby re-elected a Director of the Company.*"

Mr. JOHN DENISON PENDER: I have the pleasure of seconding that.

The resolution was carried unanimously.

The CHAIRMAN: I think that one of the shareholders has the next resolution to propose.

Mr. WEIR: The resolution relates to the appointment of auditors, and I beg to move—

"*That Mr. Henry Dever and Messrs. Welton, Jones, and Co., both of whom now retire, be and they are hereby re-elected auditors of the Company for the current year at a remuneration of £100 each.*"

Mr. W. GRIFFITH: I am sure that we are indebted to these gentlemen for the work which they do for the Company, and I second their re-election. I regard their remuneration as small, considering the work done by them.

The CHAIRMAN put the resolution, and having declared it carried, said: That, I think, closes the business of this very pleasant and very satisfactory meeting.

Mr. NEWTON: I rise as a convert to propose a vote of thanks to the Directors for the successful way in which they have managed the affairs of our Company, and I think that our acknowledgments are particularly due to our Chairman. I feel, with regard to what has been said, that if certain other Companies had had the straightforward criticisms which in the earlier years of this Company I passed upon it there would not have been so many disasters as we have seen in the commercial world. The Directors of Companies in too many cases have had adulations offered them, whereas criticisms would have been far better in the interests of their shareholders. When we see such results as are now presented to us in the case of this Company criticism is disarmed. Probably there is no joint-stock company in existence which publishes such full and ample details of its position. I sometimes think now that I urged too much when I spoke in favour of your publishing fuller details, because I sometimes think that you lay your business too bare. Fortunately, however, we have not too many competitors, having one of those beneficial monopolies which advantages everyone. I think I shall be in order now by proposing this resolution, giving our thanks to the Chairman and the Directors.

Dr. WALLER: I claim the right to second this resolution, so that I may make an observation to my good friend the convert. I know nothing more creditable to a man's candour and judgment than when he finds he has been in the wrong he unhesitatingly turns and acts in the right. I hope that he will long continue to give his able assistance now in your favour.

Mr. NEWTON put the resolution to the meeting, and it was carried unanimously.

The CHAIRMAN: Gentlemen, on behalf of my colleagues and myself I very warmly thank you. There is no encouragement so great, so stimulating, as that of the approval, six months after six months, of the body of our shareholders in the work that we have done. Dr. Waller has been a kind and generous supporter for a great many years; for we are getting old now in our work. I may say for Mr. Newton that he was once a very hard master; but, after all, when I look back, I see that he had a good deal of justice on his side. I may tell Dr. Waller that it was a long, a tough, and a very hard job to convert Mr. Newton, and we did not convert him entirely until he saw that the whole thing was conducted properly, and that we were all doing what we ought to be doing. When I look round at these meetings, and remember the days that are past and gone, the opposition we had, and the determined way we persevered, I should feel regret, and deep regret, if I missed Dr. Waller and Mr. Newton from our gatherings. The men who have known us from the beginning and who have stood by us to the end are the men I admire. Whenever they can point out anything in our conduct that ought to be amended, you may depend upon it that very full consideration will be given to the matter. I may say that I am going away for a couple of months to get beyond the cold weather that is prevailing here; but I may state that I am going to some of our stations in the Levant and other places, and therefore I shall again come in contact with our work-people. You would be astonished to see how delighted they are at receiving a visit from the Chairman. The more we can keep in touch with our *employés* the better we shall get our business done, and greater efficiency will be the result.

The proceedings then terminated.

Direct United States Cable Company (Limited).

The twenty-ninth ordinary general meeting of this Company was held at Winchester House, 50, Old Broad-street, London, on Friday, 15th inst., under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. T. Finnis) read the notice convening the meeting and the minutes of the last general meeting.

The CHAIRMAN then said: Gentlemen, this meeting being duly constituted, I think you will all agree with me that we ought to give expression to our deep and warm sympathy with the Royal Family in the great bereavement which they have sustained by the death of the Duke of Clarence. I believe that this sympathy is universal. Only a month ago the country was jubilant at the prospect of a marriage which would give increased strength to the Crown. That prospect has passed away, and I may say that that doubly increases the sorrow which we all feel at this sad event. Passing to the business of the meeting, he said: I shall, as usual, go over some of the figures of the report, in order that you may have more complete knowledge of the working of our system during the last six months. The revenue for the half-year to December 31st last, after deducting outpayments, amounted to £45,402, and the working and other expenses, including income-tax, but exclusive of the cost of repairs, absorbed £17,673, leaving a balance of £27,729 as the net profit of the half-year, making, with £3,502 brought forward from the previous half-year, a total of £31,231, which has been appropriated as follows:—Interim dividend of 3s. 6d. per share for the quarter to September 30th, £10,624; interim dividend of 3s. 6d. per share for the quarter to December 31st, £10,624: amount set aside for reserve fund, £5,000; balance carried forward, £4,933, making a total of £31,231. The revenue, as compared with that of the corresponding period of the previous year, shows an increase of £2,055, but the traffic generally has not been brisk. The McKinley tariff has, no doubt, restricted trade in many quarters, and but for the large operations in grain owing to the deficient harvest in Europe, our revenue would probably have shown a falling off. The expenses in London show as follows: Increases of £129 in salaries, and £13 in office expenses, and a reduction of £23 in printing and stationery, the remaining items being practically the same as heretofore. The expenses at stations show increases of £375 in salaries, wages, and allowances, and £63 in rent, rates, and taxes; and reductions of £40 in maintenance, £21 in travelling, £78 in repairs and renewals, and £37 in printing and stationery. These expenses on the whole show an increase of £290, largely due to the new branch station at Spruce-street, New York, referred to in my remarks at the last half-yearly meeting. In the remaining expenditure a reduction of £159 is shown in insurance and storage of cable, while on the other hand a sum of £730 is written off for depreciation of spare cable and cable tank. The reserve fund account has been charged with £4,478 for cost of repairs of cable. At the same time it has been credited with £4,303 interest on the investments, and with £5,000 from the revenue account, increasing the balance of reserve fund to £259,680. 8s. 8d. The investments remain unaltered from last half-year, and their present market value continues considerably in excess of their cost to the Company. Now, gentlemen, these are the hard facts connected with last half year, and in looking over the remarks which I made when I addressed you six months ago I find that I told you then everything that I could possibly bring before your notice which would interest you. To-day I have very little further to say than that we are going on fairly well. The McKinley tariff, as I have said already, rather interferes with us, but that has been pulled up to some extent by the increased traffic caused by the conveyance of grain, and also by the general movement in America at the present time in regard to railway stocks. As I have said before, whenever there is a movement in that way we get some share in it, as shown by

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our returns. There is no doubt also that the preparations for next year's Exhibition will help us to some extent; but still, we have got this fact to face—that we have rather more cables in the Atlantic than are required to do the work, and until such a growth of traffic comes as to fully employ these cables, I do not think we can look forward to any very large increase in our returns. I see in the papers—and I daresay you also see it as well, and ask yourselves why it should be so—that the Commercial Cable Company's shares are selling somewhere about £150. I believe there is very little of that stock held in England, but I believe a good deal of it is held in Canada, where a large amount of it was bought some years ago; but it is held in only a few hands, and they might just as well make it 200 as 150, as far as the general public is concerned. Is there any reason why that stock should be at that price when Anglo-American stock and our stock is at about 50 per cent. discount? With the price quoted of £150, the Commercial Company pay 7 per cent. upon their nominal capital, but taking it at that advanced price it only gives the man who buys it £4. 13s. 4d. per cent.; whereas any man can buy our shares at 50 per cent. discount, or very nearly so. We are paying 3½ per cent. upon our par value of £20; so the man who buys our shares gets 6¾ per cent. or 7 per cent. for his investment, against about 4½ per cent. on his investment in the Commercial Company. That is a very striking figure, and any man who has watched this thing will probably satisfy himself that, after all, there must be some reason other than the working of the cable to account for the market price. The Direct Cable probably carries messages in the shortest space of time that they have ever been conveyed across the Atlantic. We carried the news of the Derby one year in less than a minute to New York. The Anglo Company has four cables, the Western Union two cables, and we have one cable, so that we are working with seven cables against the Commercial Company's two cables. We know that the command of the carrying power, as we have it, enables us to convey the traffic quicker than it can be done by any other means; and therefore I hold that there is no reason that I can see for the price which I have mentioned being quoted for the Commercial Cable Company's stock, except for a certain amount of prejudice and a certain amount of sentiment. Whether its price will be maintained it is impossible to say; but if you take my advice, I say rather invest and get 7 per cent. out of something that may rise to par, than invest in something that may go down to par. This is almost all that I have to say to you. During the past six months we have had one repair, and I am glad to say that in the course of effecting that repair we took up a part of the cable, which satisfies us that, although our cable has attained the good age of 17 years, it has a considerable number of years of "life" in it yet. Every repair we make we put in new cable, and I think I may say that our belief in the "life" of cables is growing. Whenever a cable is broken we never lose time in making the repair, a ship being sent out promptly to do the work. That is not generally the case with cable repairs, but we think it right to remedy as soon as possible any interruption that may take place. I hope when I see you next time that I shall be able to tell you that we are going on satisfactorily. So far, I do not think anyone has any reason to complain. You can buy our shares to-day to give you 6½ per cent. or 7 per cent., and I do not think that that is a bad return. With these remarks I beg to move:—

"*That the Report of the Directors, dated January 5, 1892, together with the statement of accounts to December 31, 1891, annexed thereto, be and the same are hereby received and adopted.*"

Mr. WILLIAM FORD: I beg to second the resolution.

The CHAIRMAN then invited discussion; but no one rising to address the meeting, he put the resolution, which was carried.

A vote of thanks to the Chairman and Directors was then proposed, seconded, and carried unanimously.

The CHAIRMAN, in reply, said: I am very much obliged to you for your kind words. We are doing our very best to promote the welfare of the Company. It is a pleasure to meet you every half-year, but it would be still more pleasant to me if I could tell you that we were going to give you an extra ½ or 1 per cent. However, I hope good times are coming, and should they arrive you may depend upon it that we shall be able to take advantage of them, and in that way you will be benefited.

The proceedings then terminated.

Anglo-American Telegraph Company (Limited).

The following is the report of the Directors, to be presented to the ordinary general half-yearly meeting of the proprietors, to be held at Winchester House, 50, Old Broad street, London, E.C., on Friday next, the 29th inst., at 2 p.m.

The total receipts from July 1st to December 31, 1891, including the balance of £527. 4s. 10d. brought forward from the last account, amounted to £164,121. 9s. 4d. This sum, however, is subject to revision, as the lawsuit between this Company and the Paris and New York Telegraph Company is still pending before the Court of Appeal. The traffic receipts show an increase of £6,157 as compared wfth the corresponding period of last year; but, as will be seen from the revenue account, this sum includes the adjustment of balances to June 30th last. The total expenses of the half-year, including repair of cables, &c., as shown by the revenue account, amount to £63.507. 3s. 4d.

Interim dividends of 12s. 6d. per cent. on the ordinary stock, and £1. 5s. per cent. on the preferred stock, were paid on the 31st October last, absorbing £43.750, leaving a balance of £56.864. 6s., out of which the Directors recommend the proprietors to declare final dividends of 16s. per cent. on the ordinary stock, and £1. 12s. 6d. per cent. on the preferred stock, amounting to £56,000, making a total distribution for the year ended December 31, 1891, of £2. 12s. 6d. per cent. on the ordinary stock, and £5. 5s. per cent. on the preferred stock, leaving £864. 6s. to be carried forward to the next account.

The Company's repairing s.s. "Minia" has been engaged during the past half-year in the repair of the 1880 cable, the Brest St.-Pierre cable, the North and South Placentia cables, and the Duxbury cable. The "Minia" has also been employed in laying a cable from North Sydney, Cape Breton, to Canso, Nova Scotia, connecting this Company's system with the Western Union Company's cables between Canso and New York, thus providing an additional and alternative route, which, in the event of sudden pressure of business, or breakdown on the land lines, will be of great value. The new line completes through cable communication between England and New York City. The cost of the new cable has been charged to renewal fund.

The Company's cables and land lines are in good working order, with the exception of the Brest-St.-Pierre cable, which was again broken on November 18th last, at about 275 miles from Brest.

It is expected that the law-suit still pending between the Anglo Company and the Paris and New York Telegraph Company will be argued before the Appeal Court of Paris during the course of the coming month.

In accordance with the Articles of Association, two Directors of the Company, Francis A. Bevan, Esq., and Charles Burt, Esq., retire at this meeting, and being eligible, offer themselves for re-election. Mr. Joshua Dean and Mr. John Gane, F.C.A., the auditors, retire, and offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

CENTRAL ENGINEERING AND SHIP REPAIRING COMPANY (LIMITED).—This Company was registered on January 12, 1892, with a capital of £9,000, in £10 shares, by Kerr and Lanham, 3, Chichester-rents, Chancery-lane, London, W.C. The objects are to acquire and carry on the business of shipbuilder, ship repairer, engineer, engineering tool maker, tin and copper smith, boiler maker, iron and brass founder, &c., carried on by Mr. D. J. Morgan and others at the Central Engineering and Ship Repairing Works, Bute Docks, Cardiff.

TYNE DOCK LAND COMPANY (LIMITED).—This Company was registered on January 12, 1892, with a capital of £60,000, in £12 shares, by T. W. Rossiter, 7, Ely-place, London, E.C. The objects are to enter into an agreement with the Jarrow Chemical Company (Limited) and John Stableford, its liquidator, being a reconstruction agreement of the said Jarrow Chemical Company (Limited), and to sell for cash or for fully paid up shares in any other company the Company's shares and interest in two patents granted to James Shannan Stevenson for "Improvements in the manufacture of elements or plates for secondary batteries or electrical accumulators" and "Improvements in or connected with the manufacture of secondary battery elements," acquired under the reconstruction agreement.

AMERICAN CAMERA COMPANY (LIMITED).—This Company was registered on January 13, 1892, with a capital of £15,000, in £1 shares, by J. Boss, 10, Colchester-street, London, S.W. The objects are to acquire and take over as a going concern the business carried on by Mr. Walter P. O'Reilly, under the style of the American Camera Company, at 397 and 399, Edgware-road, W., and 124, Old Broad-street, E.C., of manufacturers and dealers in photographic, electrical, optical, chemical, and scientific instruments, apparatus, and requisites of every description.

ELECTRICAL ADVERTISING SYNDICATE (LIMITED).—The statutory return of the above Company named, made up to December 29, 1891, was filed on January 12, 1892. The Company was registered on April 27, 1891, with a nominal capital of £10.000 in £10 shares, to acquire all or any patents or such parts or shares thereof as may be agreed upon, for Upward's method and apparatus for the application of electrical energy to the purposes of advertising, and to work the same. At the time of making-up 907 shares have been taken up, and, although nothing has been called on any of the shares, £9,070 has been paid. Registered office: Victoria-mansions, Victoria-street, London, S.W.

ELECTRIC WELDING COMPANY (LIMITED).—The first annual return of the above-named Company, made up to January 5, 1892, was filed on the 14th following. The Company was registered on May 1, 1890, with a capital of £460,000, in £10 shares, to acquire and work certain patents in connection with the welding, forging and brazing of metals by electricity. The shares are now divided into 45,000 ordinary and 1,000 founders' shares. At the time of making up, 25,000 ordinary and 617 founders' shares had been taken up, and upon 16,667 ordinary shares £6 per share had been called, while upon the founders' shares the full amount had been called. The remaining 8,333 ordinary shares had been issued and considered as fully paid. The calls paid amount to £70,726. 10s., while the calls in arrears amount to no less than £102,113. 10s. A glance through the list of shareholders shows that many are resident in America, most of them hold 49 ordinary and 1 founders' share. Registered office: 6, Great George-street, Westminster, London, S.W.

CITY NOTES, &c.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—The Directors have declared an interim dividend upon both the ordinary and preference shares of the Company at the rate of 6 per cent. per annum for the six months ended December 31st last, payable on February 15th next. The transfer books of the Company will be closed from the 20th to the 27th instant.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended January 17th amounted to £836, as against £765 for the corresponding period of 1891, an increase of £71.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—A circular has been issued by this Company in which the Directors offer the

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unissued ordinary shares (9,848 in number) to the shareholders on the Company's register on January 14th inst., as was arranged at the recent statutory meeting. The shares are issued *pro ratâ*. The first payment of £3. 5s. per share is due to-morrow (Saturday), and unless this amount is paid on or before that date the allotment is forfeited. After the second payment of £3 per share on February 1st next the shares now to be allotted will rank *pari passu* in all respects with the existing shares.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This Company announce the payment, by warrant on February 1st next, of the interest for the half-year ended January 31st on their Four per Cent. Mortgage Debenture Stock. The transfer books will be closed from the 27th to 30th instant, both days inclusive.

ELECTRIC FITTINGS HIRING AND MAINTENANCE COMPANY (LIMITED).—The Directors of this Company announce that one founders' share will be placed at the disposal of every subscriber for 50 ordinary shares in the Company.

NATIONAL TELEPHONE COMPANY (LIMITED).—Mr. James Staats Forbes, one of the vice-presidents, has been unanimously elected the President of this Company, in succession to the late Mr. Frederick Richards Leyland.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the two weeks ending January 15, 1892, were £2,331, as compared with £2,792 for the corresponding period of last year, a decrease of £461.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Jan. 13.	Price Tuesday,* Jan. 19.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Jan. 19. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/6	Anglo-American	50½ 51¼	50½ 51¼	5 1 11	Jan., Apr., July, Oct.	51	50½
£2,849,510	Stock	25/0	Do. Preferred	89 90	89½ 90½	5 11 1	" "	90	89
£2,849,510	Stock	5/0	Do. Deferred	13½ 13¾	13½ 13¾	..	" "	13⅛	13½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	98 101	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10½ 11	10½ 10⅝	7 12 5	Mar., June, Oct., Dec.	10⅝	10⅜
£68,200	£100	5%	Do. 5 per Cent. Bonds	102 105	102 105	4 15 3	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 5	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	150 155	153 157	4 9 2	April and October ..	..	..
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 8	" "	17	..
12,921	5	2/0	Direct Spanish (£4 paid)	2½ 3½	2½ 3½	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9½ 10½	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States xd	11 11½	10½ 11½	6 5 0	Jan., Apr., July, Oct.	11½	10½
400,000	10	2/6	Eastern xd	14½ 14¾	14½ 14¾	4 10 5	" "	14 7/8	14 7/8
70,000	10	6%	Do. 6 per Cent. Preference xd	15 15½	15 15½	3 17 5	" "	15⅜	15⅛
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106 109	106 109	3 13 5	May and November	108½	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	110	..
250,000	10	2/6	Eastern Extension xd	15½ 15⅝	15 15½	4 11 10	Jan., Apr., July, Oct.	15½	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107 110	107 110	3 12 9	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb..1900	101 104	101 104	4 16 2	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99 102	99 102	3 18 5	Febuary and August	101	100½
180,227	10	2/0	Globe Telegraph and Trust	9½ 10	9½ 10	5 7 6	Jan., Apr., July, Oct.	10	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	14½ 15	14½ 15	4 0 0	" "	15	14¼
150,000	10	5/0	Great Northern	19 19½	19 19½	4 7 2	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41 43	41 43	5 16 3	May and November	42⅜	42⅜
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	7½ 8½	7½ 8½	4 16 11	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	116 121	116 121	4 18 4	" "	116	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	..	..
30,000	10	2/0	West Coast of America	4 5	4 5	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	99 103	99 103	7 15 4	June and December	101	100
88,321	10	1/0	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	..	" "	..	..
34,568	10	6%	Do. 6 per Cent. 1st Preference	9 9½	9 9½	6 6 4	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7½ 8½	7½ 8½	7 1 2	" "	8½	..
67,007	15	6/0	Western and Brazilian	10 10½	10 10½	7 2 10	" "	10½	10 7/8
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6½ 6⅝	6½ 6⅝	5 7 8	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	3¾ 4¼	3¾ 4¼	..	" "	¼	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104 107	104 107	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	104 107	104 107	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance.	⅜ ½	⅜ ½	8 7 7	May and November	½	..
220,000	£1	4·76d.	Oriental (11s. paid)	7/16 ⅝	7/16 ⅝	6 3 11	Yearly	..	..
438,984	5	2/6	National	4½ 4⅝	4½ 4⅝	6 17 2	June and December	4 7/8	4⅝
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12¼ 12½	12¼ 12½	4 14 1	" "	12½	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12 12½	12 12½	4 16 0	" "	12 7/8	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	105 108	104 107	4 4 1	January and July ..	106½	105
58,000	5	1/0	United River Plate	1 2	1 2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	80 90	80 90	5 11 1	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£6 paid)	6 6½	6½ 6⅝	..	..	6 7/8	6 7/8
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	..	4½ 5	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	..	5½ 6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	5½ 6	..	January and July ..	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2⅝ 2¾	2⅝ 2⅝	..	March	..	..
10,000	£5	3½%	Do. (fully paid)	4¼ 5¼	4¼ 5	..	March	..	..
111,000	5	..	London Electric Supply	1⅛ 1⅜	1 1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½ 10	9½ 10	..	..	10	9⅝
6,318	10	..	Notting Hill Electric Lighting (fully paid)	5½ 6⅛	5½ 6⅛	..	..	..	..
18,630	£5	3/6	St. James' and Pall Mall	8½ 9	8½ 9	..	..	9	8½
7,900	£5	7%	Do. 7% Preference	7 7½	7 7½	..	..	7½	7
42,853	5	..	Westminster Electric Supply (fully paid)	6½ 7	6½ 7	..	..	6⅞	6⅝
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	6%	Brush Electrical Engineering	3½ 3⅝	3½ 3⅝	..	..	3 7/8	3½
69,996	2	6%	Do. 6 per Cent. Preference	2½ 2⅝	2½ 2⅝	5 1 1	..	3	2 5/8
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5⅛ 6	5⅛ 6	5 16 8	January and July ..	..	..
17,120	5	17%	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	6 6½	6 6½	..	—	6½	6 1/8
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅝ 3⅞	3⅝ 3⅞	..	—	4	3⅝
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20½ 21½	20½ 21½	4 15 3	February & August	..	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 106	103 105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	4 6	3½ 4½	..	..	..	..
11,334	£10	8/0	Do. Preference	8½ 9½	8 9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅜ ½	⅜ ½	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	4 4½	3½ 4½	9 1 10	May and November	3⅛	3⅜
36,250	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July.....	42½	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100 103	100 103	4 17 1	January and July ..	102	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	.. ..	1⅜ 1⅝	5 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	..	3½ 3¾	10 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	—	—	..	..
60,000	£10	..	City and South London Railway	2½ 3½	2½ 3½	..	..	..	..

* The Stock Exchange was closed on Wednesday, January 20th.

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THE ELECTRICIAN:

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NOTES.

Although the second half-year's working of the City and South London Railway has not brought financial consolation to the holders of the Ordinary shares, the Directors are able to go one stage further in the dividend-paying process and pay 5 per cent. on the Perpetual Preference shares in addition to the Debenture interest. The gross receipts show an increase of nearly 8 per cent. over those of the first half of 1891, while the working expenses remain practically stationary. The number of passengers has increased by 14 per cent., the total carried since the opening of the line on December 18, 1890, being close upon 5½ millions.

It is a great pity that so much unnecessary secrecy and unexplained delay has postponed the publication of the Lauffen-Frankfort transmission experiments. If the plant had been erected for some industrial purpose, business reasons might have interfered, but it was set up as a leading feature of a popular exhibition. An exhibition, if aiming at something more than providing a tea or beer garden, is nothing if not demonstrative, and fails in its purpose if it does not set forth in full and disclose completely the objects for which it has been held. Some figures relating to measurements of the multiphase plant have been semi-officially published in the *Schweizerisch Bauzeitung*, and are to be found in another column. The efficiency, exceeding 72 per cent., is very satisfactory, but the information is altogether too vague to enable fair comparisons to be made with other systems. The proportions of capital outlay which were devoted to plant and to the conductor are interesting, but £10 per horse-power for the former, if accurate and inclusive, is, perhaps, a strong point; since it is a fair proof, not so much of economy, as of simplicity of construction, and, therefore, of cheapness of up-keep.

The ingenious suggestions which were put forward by Prof. FitzGerald at the Physical Society last week, and to which Mr. Garrett makes an interesting addition in his letter which appears in another column, deserve careful experimental investigation. The expenditure of energy which would be required to maintain the oscillations would be inconceivably small in the presence of a well-tuned resonating apparatus; and if there is any remote chance of success each method should be given a trial. It has been said, and it is still safe to say, that no well-informed electrician would in 1875 have seriously contemplated for a moment the construction of a pair of Bell telephones as transmitting and receiving instruments even for musical sounds, to say nothing of articulate speech. The marvel that the quiver of an iron diaphragm can set up an appreciable current is equalled only by the greater marvel that these currents can generate an audible sound at a distance of many miles. If a battery contained in a thimble will deflect a magnet loaded with a mirror at the remote end of an Atlantic cable, what a tiny effort, if properly applied, may deflect a spark and determine which of two knobs it shall strike! If a clock hanging on a nail can impart such impulses through a wall as can affect the motion of the pendulum of another clock, such minute differences of potential as may be set up in a bismuth wire might maintain the oscillations of a current in the manner suggested by Mr. Garrett.

Mr. Garrett's device is remarkable in one respect, inasmuch as it is possible by its means to produce a current alternating at the same frequency as the original current, or twice as rapidly. The alteration in the resistance of the bismuth depends only on the strength of the magnetic force, and not upon its direction, so that the alternating magnetic field due to the current in the solenoid will cause the secondary current to fluctuate twice as often as the primary. If, however, a permanent magnetic field be superposed upon the weak field due to the current in the coil, so that the direction of the lines of force is always the same, the two currents will be of the same frequency. There seems, however, slender hope that this device will be useful for the purpose suggested. Apart from the doubt whether bismuth would respond to the influence of such rapid currents, the strength of the field produced by electric oscillations is so small that the effect on the bismuth would be infinitesimal; and, moreover, the impedance presented by the solenoid to such oscillations would be so enormous that the current would probably find it easier to spark across the terminals than to traverse the coils.

Our correspondent who thinks that we shall scarcely endorse the opinion which we have already cited, to the effect that an attempt to answer the question "What is Electricity?" is to waste time, is mistaken; for we are beginning to think that the present discussion is not only a waste of time but a waste

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of our space. The two letters which we publish this week are undoubtedly heterodox; and while it is only fair that such views should have a hearing, we shall have to close our columns to any more contributions of this character.

MR. PAULL does not appear to have studied Prof. OLIVER LODGE'S "Modern Views," and seems to have had only second-hand information on Prof. POYNTING'S contributions to our knowledge of energy-paths. A much less important omission on the part of our correspondent is the perusal of a theory which we ventured to put forward in the article which gave rise to this correspondence, and which appeared in our issue of December 18th. We assumed a magnetic molecule, and defined its magnetism as the property whereby a strain is set up in the neighbouring ether. This postulate, we think, is a modest one in the present state of our knowledge of magnetism. We went on to say that, this being granted, it is only necessary to assume that if relative motion is produced between this molecule and a conductor, all electrical phenomena may be accounted for, and no conception of "current" or "electricity" is in the least necessary. None of our correspondents have noticed this theory; and until it is demolished we see no reason whatever for supposing that electricity exists, and, *à fortiori*, that a current ever flows.

THE information which Mr. SYDNEY MORSE is good enough to give us on the subject of Rural Sanitary Districts and Urban Sanitary Districts will be appreciated by those of our readers who may meet with these phrases in their dealings with Corporations and other local bodies. We have no fears that the Board of Trade will take a hint from our remarks and prohibit the use of overhead wires in the "Urban" districts. We have heard these names used in connection with the difficulty of defining "town" and "country," and it is highly probable that the Board of Trade have already satisfied themselves that to accept this "sanitary" definition in connection with overhead wires would press too harshly on electric lighting.

Jarrow.—The Corporation are inviting electric lighting tenders for supplying private customers with the electric light.

Appointment.—M. Violle, of incandescent platinum standard fame, has been appointed M. Edmond Becquerel's successor at the Conservatoire des Arts et Metiers.

Applied Electricity.—Mr. W. Perren Maycock will lecture on "Applied Electricity," on Wednesday next, at 8 o'clock, at the Whitgift Grammar School, Croydon.

Bermondsey.—At a recent meeting of the Bermondsey Vestry the General Purposes Committee reported that they had instructed the surveyor to ascertain upon what terms the streets could be lighted by electricity, as from March 25th next.

The Price of Aluminium.—The Aluminium-Industrie-Actiengesellschaft, of Neuhausen, says *Industries*, has recently reduced its price for pure aluminium from £40 to £25 per 100 kilogrammes. The daily production at these works now amounts to one ton.

St. Petersburg Electrical Exhibition.—The St. Petersburg Electrical Exhibition was formally opened on Saturday last by M. Vishnegradski, Minister of Finance, who was accompanied on the occasion by M. Durnovo, Minister of the Interior, and a number of distinguished personages.

Royal Society.—The following papers were down for reading yesterday before the Royal Society: "On the Melting Points of the Gold-aluminium Series of Alloys," by Prof. Roberts-Austen, F.R.S.; and "Colour Photometry," by Captain Abney, F.R.S., and Major-General Festing, F.R.S.

Electric Traction in Russia.—The first electric street railway in Russia, says the *Engineer*, will be constructed in Kiew, a city of about 130,000 inhabitants, and situated on the river Dnieper. This street railway will use the overhead system, and will be ready for operation in the summer.

Clothworkers' Scholarship.—This scholarship, entitling the prizeman to five years' training at the Finsbury Technical College and the Central Institution, together with a sustentation allowance, has again been won by a pupil of the St. Thomas Charterhouse Schools, E. Dixon, aged 13½ years.

The Electric Supply Mains at Liverpool.—There was a small scale repetition on Wednesday morning last week of the short-circuit fire which took place a few days previously in one of the supply boxes of the Liverpool Electric Supply Company (see *The Electrician*, January 15th, p. 269).

The Leeds Electric Tramway.—Since the opening of the Roundhay Park line Mr. Graff Baker's cars have carried 90,000 passengers, the aggregate daily mileage being 500 miles. The maximum numbers of passengers which can be carried in any single day is 6,000, a limit which was reached on Boxing day.

The Howard Lectures.—In consequence of the illness of Prof. W. C. Unwin, F.R.S., the Howard Lectures on "The Development and Transmission of Power from Central Stations," which he was announced to deliver before the Society of Arts on February 5th and five following Friday evenings, have been postponed.

Coast Communication.—A Government Commissioner has just been visiting several ports on the Bristol Channel coast with a view of obtaining information and suggestions to lay before the forthcoming Commission, which will investigate the whole matter of improved communication by telegraph along the sea coast.

The Probable Future of Condensers in Electric Lighting.—In Mr. Swinburne's article on this subject, which was reprinted from *Industries* in our issue of January 1st, there was an error as to the exciting current of the triple-current motor mentioned on p. 228. The exciting current of a two-horse motor should be 3 amperes in each circuit, making 630 apparent watts at no load.

Mr. Edison.—We learn from our Correspondent in Russia that Mr. Edison is expected to arrive at St. Petersburg next week, with the object of inspecting the Electrical Exhibition and being present at some of the experiments which are being made there with the machinery exhibits. The Americans in St. Petersburg are making great preparations to give Mr. Edison a cordial reception.

Dublin.—The installation of the electric light by the Dublin Corporation is going on so far favourably. The engine and dynamo building is all but complete, and the laying of the mains in the compulsory area is progressing rapidly. The mains are laid underneath the flagway, near the edge of the footpath. Metal junction boxes are being fixed at the angles of branch streets, and for every two houses a service box is inserted, so that service wires for each two houses may be taken from one point in the main.

Electrical Engineering Course at Sydney University.—The University of Sydney have recognised the claims of electrical engineering by adopting the following proposals by Prof. Threlfall at the last meeting of the Senate:—"That the faculty cordially approves of Prof. Threlfall's proposal for the establishment of a curriculum in electrical engineering, and recommends that it be carried out by the Senate, including the suggestion of a grant of £300 for the necessary apparatus." It was also decided that the curriculum should lead up to the degree of Bachelor of Engineering in Electrical Engineering.

Chicago Exhibition.—The first meeting of the Electricity Committee of the Royal Commission was held on Tuesday afternoon, 26th inst. Present:—W. H. Preece, F.R.S., in the chair; Sir Frederick Abel, F.R.S., Colonel R. T. Armstrong, R.E., R. E. B. Crompton, Prof. James Dewar, F.R.S., Major-

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General E. R. Festing, F.R.S., Prof. George Forbes, F.R.S., Prof. G. Carey Foster, F.R.S., Edward Graves, Prof. D. E. Hughes, F.R.S., Gisbert Kapp, J. C. Lamb, W. M. Mordey, J. Fletcher Moulton, F.R.S., Prof. John Perry, F.R.S., Alexander Siemens, Prof. Silvanus P. Thompson, F.R.S, with Sir Henry T. Wood, Secretary of the Royal Commission.

The Association for the Improvement of Geometrical Teaching.—Messrs. Whittaker and Co. inform us that they have been appointed the London publishers of the general reports of this Association. In addition to the Papers mentioned by Mr. Langley on p. 284 of our issue of January 15th, and to the Papers read at the recent general meeting of the Association (see *The Electrician*, January 15th, p. 273), the following appear in the General Reports:—A Geometrical Investigation of (i.) Frégier's Point (G. T. Bennett, B.A.), (ii.) Cosh $u + \sinh u = \exp(u)$ (R. Levett, M.A.); Geometrical Theorems (Dr. J. S. Mackay); Geometrical Odds and Ends (E. M. Langley, M.A.).

Obituary.—Mr. Alexander Watt, whose death occurred on Friday, January 15th, was born in 1823. In 1839 he took up the then novel process of electrotyping. In 1885 he published a treatise on "Electro-Deposition." In the year 1887-8 he contributed a series of Papers to *The Electrician* on "The Electrolysis of Iron Salts," and to the *Electrical Review* Papers on the "Electrolysis of Aluminium Salts," "Electrolytic Coloration of Metals," &c., &c. Mr. Watt gave practical instruction and advice to a considerable number of persons in the art of electro-deposition, both at home and abroad, and had been engaged in several important electrolytic lawsuits. He also delivered occasional lectures on the electro-deposition of metals and other subjects, and was the author of a number of works upon the subject of "Electro-Metallurgy," "Electro-Deposition," &c.

Electric Traction and the Liverpool Tramways.—At the recent meeting of the shareholders of the Liverpool United Tramways and Omnibus Company, the Chairman remarked that they seemed to be still no nearer to a system of mechanical haulage that would supersede horses. Electricity answered well as a haulage power, but commercially the price was far more than horses. They had an offer of electrical haulage at 7d. per mile, with an additional charge of £1,600 for each car, with its electrical machinery attached. The 7d. per mile was much more relatively than the cost of horse haulage, exclusive of the capital outlay of £1,600 for each car; and, as they had 234 cars, the total outlay would amount to £374,400. The same Company offered the Glasgow Corporation the same service at 3½d. per mile, the physical difficulties of Liverpool accounting for the enormous difference.

Electric Light Competition in Holborn.—At a recent meeting of the Holborn Board of Works Mr. Claremont, of the Metropolitan Electric Supply Company, waited on the Board to ask them not to consent to the application of another company to supply Holborn with electric light. There was not sufficient demand in Holborn, he said, to warrant the establishment of another company in the district. His company had left no stone unturned to do justice to Holborn. They had endeavoured in every way possible to give satisfaction, and had never had a complaint or a breakdown; and, besides, their price was cheaper by ¾d. a unit than that of any other company in London. In reply to a member, Mr. Claremont said that the company's station was capable of supplying far more light than they had application for. Mr. Moss, on behalf of the County of London Electric Company, asked the Board to assent to the application of his company. The Board decided to grant the application of the County of London Electric Company.

Interurban Telephony in Bulgaria.—The new telephone service between Sofia and Philippopolis, a distance of a hundred miles, was recently inaugurated with considerable ceremony by Prince Ferdinand. Prince Ferdinand inaugurated the new line with a patriotic speech, addressed to the Prefect of Philippopolis, which was greeted with loud applause, and to which the Prefect made a suitable reply. The Ministers present, and several others who were invited to do so, then spoke by telephone with persons at the Philippopolis end of the wire. The hearing was perfect. At Philippopolis the inauguration was attended by the Prefect, the clergy, the chief civil and military officials, and the consular body. After the exchange of a considerable number of communications, those present at the ceremony, both at Sofia and at Philippopolis, were entertained at *déjeûners*, at which several patriotic addresses were delivered, the speakers dwelling especially upon the progress made by the principality, of which the establishment of telephonic communication between the two chief cities afforded a fresh proof.

Electrical Bills in Parliament.—Among the Bills which have passed the Examiners on Standing Orders of the House of Commons are the following:—The New Telephone Company, Baker-street and Waterloo Railway, Waterloo and City Railway, Great Northern and City Railway, London County Council (Subways), Central London Railway, Liverpool Overhead Railway, the National Telephone Company and the Ward Electrical Car Company Bill, authorising agreements between the Company and local authorities for the running of electrical carriages in the streets. In the case of the London, Tottenham, and Epping Forest Railway Bill, which appeared on the list, no appearance was entered, and it was struck off. The Bill of the New Telephone Company is a measure for dissolving and reincorporating the Company, and defining its capital, objects, and powers. The clause of the Bill which relates to capital recites that the capital of the Company shall be £75,000, divided into 74,700 shares of £10 each and 3,000 founders' shares of £1 each, but the Company may from time to time increase its capital to an amount not exceeding £2,000,000.

Sunderland—A special meeting of the Highways Committee of the Corporation has been held to consider offers for lighting with electricity that part of the town comprised in the Provisional Order (1891). Applications had been invited by the Corporation from companies prepared to take over the powers which the Provisional Order vested in them. Two were received, viz., from the Brush Company and Messrs. Andrews and Co. The former proposed to take over the Order with all its obligations, on condition that the Corporation assisted them to form a local company, that at the end of 21 years the Corporation should have power to acquire the works as a going concern at a valuation and payment to be agreed upon for the goodwill, that they would pay a royalty of 10 per cent. on the balance of receipts over expenditure, that the Corporation should cause the main thoroughfares to be lighted at such a price as should be arranged hereafter, and that no concession of any kind should be granted to any other company. Messrs. Andrews proposed to take over the area mentioned in the Provisional Order, to supply it with electricity for lighting purposes on the alternating-current high-pressure system at a uniform charge of 3¾d. per Board of Trade unit, and to pay the Corporation a rental of £100, together with a royalty according to the consumption. They required payment for the goodwill if at the end of 21 years the Corporation wished to acquire the concern. The terms of both offers were discussed, and it was ultimately agreed to submit the same to Mr. Shoolbred, and to await his report.

Central Station Lighting in Halifax.—The Halifax Mutual Electric Light and Power Company was formed nearly two years ago by taking over the central station then being worked by Messrs. Blakey, Emmott and Co., and also that of an opposition company which has since ceased to exist. The wires, by permission of the Halifax Corporation, are all overhead, and the Company is supplying current for about 60 arc lights of 10 amperes, and 1,000 incandescent lights of 8 c.p. Two systems of charging are adopted in the town, viz., one at the rate of 12s. per 8-c.p. lamp per annum, and £12 per 10 ampere lamp per annum, and at 8d. per B.T.U. The furthest point served from the central station is about 1,700 yards. The low-tension system is adopted throughout. It has been found during the past two months that the Company could not keep pace with the large demand for current at their present premises; therefore, negotiations have been entered into with the Halifax Corporation for leasing from them a convenient site, and very shortly it is hoped that the Company will have a capacity of at least 20,000 8-c.p. lamps. Two systems of engines are used

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for driving, viz., Armington-Sims High Speed, and Tangyes. The dynamos and all other electrical fittings in connection with the installation are of the Blakey, Emmott, type; and Mr. Walter Emmott, of Blakey, Emmott, and Co., is the managing director. The meter adopted up to the present has been the "Aron," which appears to be giving general satisfaction both to the Company and to the consumers. The price per 1,000 cubic feet of gas in Halifax is 2s. net, and judging from the weekly reports of the expert who tests the illuminating power on behalf of the ratepayers, the average illuminating power is about 17 candles. Taking into account this very low price and high efficiency, the present output and very large demand for current speak very well for the prospects of electric light for the future. The whole of the wires and cables for this installation have been manufactured by the Northern Electric Wire and Cable Manufacturing Company, Halifax.

Central Station Lighting at Preston.—A temporary generating station was fixed twelve months ago, for the purpose of ascertaining the probable demand for the electric light in Preston. The National Electric Supply Company, which Company has obtained a Provisional Order for lighting the town for a term of 42 years, intended the maximum output of this station to be only 1,000 8-c.p. lamps; but long before the plant was ready for working, this number of lamps was quickly taken up on a basis of 12s. per lamp per annum. The Company to meet additional orders was compelled to fix another machine, bringing the capacity up to considerably over 2,000 lights, which quantity is now actually working, and orders for more are daily coming in. The outside wiring up to now has been overhead, there being four circuits from the central station in Corporation-street, two along pole routes through the most important thoroughfares in the town, and two over housetops, telephone fashion. The present plant, supplied by Messrs. Blakey, Emmott and Co., of Halifax, consists of three 18-unit machines and one 30-unit machine. The National Electric Supply Company now propose to put down a plant on the low-tension system similar to that now working so successfully in the St. James' district in London. The first portion of the town to be served from this station will be the compulsory area with the adjoining streets, in which it is anticipated that at least 20,000 8-c.p. lamps will be required. Distributing boxes will be laid to such places so as to ensure an even potential over the mains. A large number of meters has been introduced. The amount charged to consumers is 8d. per Board of Trade unit, with a discount of 15 per cent. if paid within 21 days. Preston with its numerous mills is favourably placed for a successful adoption of the electric light, and the way in which the engineer and manager Mr. F. F. Bennett has worked up the present installation augurs well for the future. Gas at Preston is 2s. 9d. per thousand.

The Recovery of Wasted Gutta-Percha.—In a recent number of the *Kew Bulletin* is reprinted a report of Mr. Leonard Wray, jun., dated Perak, September, 1883, on the subject of the recovery, by appropriate processes, of the vast quantities of gutta-percha wasted by the methods of collection at present in vogue. In view of the sanguine anticipations of M. Eugene Serullas in this direction, the following extracts from Mr. Wray's report may be of interest. After describing the present wasteful method of felling trees, and then cutting V-shaped notches in the bark into which the gutta-percha gradually oozes, Mr. Wray goes on to say that the amount of gutta-percha obtained from a single tree has been greatly over-estimated; exceptionally large yields from gigantic trees having been erroneously quoted as averages. Mr. Wray had a tree felled, 2ft. in diameter at a height of 6ft. from the ground, and about 100ft. high, and 100 years old; *it gave 2lb. 5oz. of fairly-clean gutta, worth only 7s. 6d.* A tree was next felled and treated in the usual Malay manner, 12oz. of gutta being obtained. Samples of the bark were then treated by various processes, simple and elaborate. The following deductions may be made from these results: firstly, the wet bark which is allowed to rot in the jungle contains fully 5·7 per cent. of its weight of gutta, or when dried 11·4 per cent.; secondly, by simply pounding or rasping and boiling the bark, nearly all the gutta which it contains may be extracted. The total weight of wet bark on the tree in question was 530lb. 5·3 per cent. of this, or 28lb., may be recovered by merely boiling and pounding. The *efficiency* of the Malay method, therefore, amounts to about 2½ per cent. In 1875 the export of gutta from the Straits Settlement and Peninsula was estimated at 10,000,000lb. Accepting these figures as reasonably correct, we must, says Mr. Wray, come to the conclusion that even if we take the amount of gutta wasted at only 30 times the weight of that collected (instead of 37), no less than 300,000,000lb. are wasted in one year, which, at 2s. 6d. per lb., means £37,500,000 worth of gutta thrown away. With the object of testing whether it would be worth while to collect, dry and send home the bark, some specimens were despatched to Kew, and tested by the India-Rubber, Gutta-Percha and Telegraph Works Company, whose chemists reported that there was so much resin present as to render the gum valueless, and that the cost of solvents for the large scale operations that would be necessary made it very improbable that the idea would prove remunerative.

The United States Patent Office.—The following extracts from the report of the United States Commissioner of Patents for the year 1890 may be of interest:—The Patent Office, he says, still awaits a suitable laboratory. The great number of applications for patents relating to metallurgical, chemical, and electrical inventions renders it necessary that a completely-equipped laboratory should be at the services of examiners and applicants for patents. An inconsiderable sum would secure the necessary apparatus and appliances. The model halls now contain about 154,000 models. The number added during the year was 535. The Commissioner regards it as nothing less than a public calamity that the Office has been compelled to suspend the reception of models, excepting in special instances, for want of space in which to store and exhibit them. He hopes that the time will come when models will again be required in connection with all applications. The Patent Office library at present consists of 59,856 volumes. During the year, 1,713 volumes were added. Section 4,904 of the Revised Statutes requires that when an application is made for a patent which, in the opinion of the Commissioner, would interfere with any pending application, or with any unexpired patent, he shall institute proceedings to determine the question of priority of invention. The Commissioner is sorry to add that it is currently believed that in some cases new parties enter the field, not so much to obtain a patent for themselves as to obstruct and postpone the rights of meritorious inventors. In his opinion a law providing that a party prevailing upon the first proceeding shall be permitted to take his patent, and that subsequent applicants shall contest priority with a patentee instead of with an applicant, would be found to constitute a practical remedy for some of the incidental evils of the system as it at present exists. The State in which most patents were granted during 1890 was New York (4,585), Wyoming coming the last on the list with 8. The most actively patenting State was Connecticut, in which 125 patents were taken out per 100,000 inhabitants, as against 4 in Mississippi. The citizens of foreign countries to whom most patents were granted were England (721), Germany (452), and Canada (371). In 1837, 436 patents were issued by the United States office; half a century after, namely, in 1887, the figure was 21,477; in 1890 the total was 26,292. During 1890 no less than 226 patents were granted in connection with electric traction (systems, motors, cars, conduits, trolleys, &c.), in addition to 66 patents for electric motors, in which electric traction was not specifically referred to. The patents for arc lamps and auxiliary apparatus numbered 50, dynamos 100, secondary batteries 98, electric meters 30, conductors and conduits 100, commutators 23, telephones 20, insulators and insulating compounds 57; galvanic batteries claimed 33 patents, and voltaic batteries 1, which was granted to Mr. Edison. Some 12 electric locomotives were patented, together with 4 galvanometers, 5 reciprocating electric engines, 7 magnetic separators 4 electric soldering irons, 9 thermo-electric batteries, 14 electric heaters, and 3 electro-magnetic clutches. Electric welding and metal working by electricity counted 25 patents. The most prolific electrical inventor seems to have been Mr. R. M. Hunter, who took out no less than 39 electric railway patents during 1890.

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ELECTROMAGNETIC THEORY.—XXIII.

BY OLIVER HEAVISIDE.

(Continued from page 218.)

§ 115. In the preceding account of vector addition, and of the scalar product and the vector product, the reader has nearly all that is needed for general purposes in geometry and in the usual physical mathematics involving vectors, so far as the algebra itself is concerned. For the addition of differentiations does not usually introduce anything new into the algebra. Thus, in the analysis of varying vectors, we have the same vector algebra with new vectors introduced, these being derived from others by the process of differentiation.

The ideas concerned in the differentiation of a vector with respect to a scalar are essentially the same as in the differentiation of a scalar. Thus, u being a scalar function of x, *i.e.*, a quantity whose value depends on that of x, we know that if Δu is the increment in u corresponding to the increment Δx in x, then the ratio $\Delta u/\Delta x$ usually tends to a definite limiting value when Δx is infinitely reduced, which limit, denoted by du/dx, is called the differential coefficient of u with respect to x. This I should be strongly tempted to call the "differentiant" of u to x, were I not informed on the highest authority that the expression "differentiant" for "differential coefficient" is objectionable. But the differentiating operator d/dx which acts on the operand u may be termed the "differentiator," as has perhaps been done by Sylvester and others. This way of regarding a differential coefficient, splitting du/dx into (d/dx) and u, sometimes leads to great saving of labour, though we are not concerned with it immediately.

The differential coefficient is thus strictly the *rate* of increase of the function with the variable, or the increase of the function per *unit* increase of the variable, on the tacit assumption that the rate of increase of the function keeps the same value throughout the whole unit increment in the variable as it has for the particular value of the variable concerned. This plan, referring to unit increment, is often very useful. The reservation involved, though it must be understood, need not be mentioned.

There is also the method of differentials, which is of some importance in vector analysis, as it can be employed when differential coefficients do not exist. Thus, u being a function of x, whose differential is dx, the corresponding differential of u is

$$du = f(x+dx) - f(x); \quad . \quad . \quad . \quad . \quad (56)$$

which, by expanding $f(x+dx)$, reduces to

$$du = \frac{du}{dx}dx, \quad . \quad . \quad . \quad . \quad . \quad (57)$$

provided we neglect the squares and higher powers of dx, that is, regard dx as infinitesimal, and therefore du also. And if there be two variables, as in $u = f(x, y)$, then we have

$$du = f(x+dx, y+dy) - f(x, y), \quad . \quad . \quad (58)$$

leading to

$$du = \frac{du}{dx}dx + \frac{du}{dy}dy, \quad . \quad . \quad . \quad . \quad . \quad (59)$$

expressing the differential of u in terms of those of x and y.

Now let the operand be a vector function of x, say, $\mathbf{E}$. For instance, x may mean distance measured along a straight line or axis in an electrostatic field, where $\mathbf{E}$, the electric force, will usually change as we pass along the line. It may change continuously in direction as well as in magnitude; that is, the change itself in $\mathbf{E}$ between two points on the line is a vector, being the vector $\Delta\mathbf{E}$ which must be added to the $\mathbf{E}$ at the first point to produce that at the second point. Dividing by Δx, the increment in x, we get the vector $\Delta\mathbf{E}/\Delta x$; and this, when the increments are taken smaller and smaller, approximates towards a definite limiting vector denoted by $d\mathbf{E}/dx$, which is, by the manner of its construction, the rate of increase of $\mathbf{E}$ with x, or the increase in $\mathbf{E}$ per unit increase in x.

We have also, in differentials,

$$d\mathbf{E} = f(x+dx) - f(x), \quad . \quad . \quad . \quad . \quad (60)$$

leading to

$$d\mathbf{E} = \frac{d\mathbf{E}}{dx}dx, \quad . \quad . \quad . \quad . \quad . \quad . \quad (61)$$

understanding that the differentials dx and $d\mathbf{E}$ are infinitesimal.

Similarly, the rate of increase of the vector $d\mathbf{E}/dx$ with x is the second differential coefficient $d^2\mathbf{E}/dx^2$; and so on.

§ 116. In semi-Cartesian form we have

$$\mathbf{E} = \mathbf{i}E_1 + \mathbf{j}E_2 + \mathbf{k}E_3. \quad . \quad . \quad . \quad . \quad (62)$$

Here the scalars E_1, E_2, E_3 are functions of x, whilst the reference vectors $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$ are constants; so we have

$$\frac{d\mathbf{E}}{dx} = \mathbf{i}\frac{dE_1}{dx} + \mathbf{j}\frac{dE_2}{dx} + \mathbf{k}\frac{dE_3}{dx}, \quad . \quad . \quad . \quad (63)$$

showing the components of the vector $d\mathbf{E}/dx$.

Similarly,

$$\frac{d^2\mathbf{E}}{dx^2} = \mathbf{i}\frac{d^2E_1}{dx^2} + \mathbf{j}\frac{d^2E_2}{dx^2} + \mathbf{k}\frac{d^2E_3}{dx^2} \quad . \quad . \quad . \quad (64)$$

shows the components of the second differential coefficient, obtained by differentiating (63).

Now, this semi-Cartesian process is quite general. Any vector function may be expressed in the form (62), and when the right member is differentiated, the differentiations are performed upon scalar functions. The same remark applies to (63) and (64), &c.; so we see that the rules for differentiating vectors, and functions of vectors, with respect to scalar variables, are the same as those for differentiating similar functions of scalars, so far as the independent action of a differentiator on the separate members of a product goes.

Thus, in differentiating a scalar product, $\mathbf{AB}$, with respect to a variable scalar, t, we have, by (23),

$$\frac{d}{dt}\mathbf{AB} = \frac{d}{dt}(A_1B_1 + A_2B_2 + A_3B_3)$$

$$= (\dot{A}_1B_1 + \dot{A}_2B_2 + \dot{A}_3B_3) + (A_1\dot{B}_1 + A_2\dot{B}_2 + A_3\dot{B}_3);$$

or, re-transforming to vectors

$$\frac{d}{dt}\mathbf{AB} = \dot{\mathbf{A}}\mathbf{B} + \mathbf{A}\dot{\mathbf{B}}, \quad . \quad . \quad . \quad . \quad . \quad (65)$$

just as if $\mathbf{A}$ and $\mathbf{B}$ were scalars. Similarly, we have

$$\frac{d}{dt}\mathrm{V}\mathbf{AB} = \mathrm{V}\dot{\mathbf{A}}\mathbf{B} + \mathrm{V}\mathbf{A}\dot{\mathbf{B}}, \quad . \quad . \quad . \quad . \quad (66)$$

as we may see immediately by differentiating the semi-Cartesian expansion of $\mathrm{V}\mathbf{AB}$, equation (41). We have also

$$\frac{d}{dt}\mathbf{AVBC} = \dot{\mathbf{A}}\mathrm{V}\mathbf{BC} + \mathbf{A}\mathrm{V}\dot{\mathbf{B}}\mathbf{C} + \mathbf{A}\mathrm{V}\mathbf{B}\dot{\mathbf{C}}, \quad . \quad . \quad . \quad (67)$$

and

$$\frac{d}{dt}\mathrm{V}\mathbf{A}\mathrm{V}\mathbf{BC} = \mathrm{V}\dot{\mathbf{A}}\mathrm{V}\mathbf{BC} + \mathrm{V}\mathbf{A}\mathrm{V}\dot{\mathbf{B}}\mathbf{C} + \mathrm{V}\mathbf{A}\mathrm{V}\mathbf{B}\dot{\mathbf{C}}. \quad . \quad (68)$$

But, although we proceed formally, as in the ordinary differentiation of scalars, as regards the properties peculiar to differentiation, yet we must always remember those which are peculiar to the vector algebra. For example, we must not only on the left sides, but also on the right sides of (67) and (68), remember the reversal of the sign of a vector product with the order of the letters.

Independently of $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$, we may proceed thus, using differentials:—

$$d(\mathbf{AB}) = (\mathbf{A}+d\mathbf{A})(\mathbf{B}+d\mathbf{B}) - \mathbf{AB} = \mathbf{A}d\mathbf{B} + \mathbf{B}d\mathbf{A} \quad . \quad (69)$$

omitting the infinitesimal $d\mathbf{A}\,d\mathbf{B}$ of the second order. Dividing by dt, and proceeding to the limit, we obtain (65).

Similarly we have

$$d(\mathrm{V}\mathbf{AB}) = \mathrm{V}(\mathbf{A}+d\mathbf{A})(\mathbf{B}+d\mathbf{B}) - \mathrm{V}\mathbf{AB} = \mathrm{V}(d\mathbf{A})\mathbf{B} + \mathrm{V}\mathbf{A}d\mathbf{B}. \quad (70)$$

omitting the second differential $\mathrm{V}d\mathbf{A}d\mathbf{B}$. So, dividing by dt, we obtain (66).

In getting (69) we have, of course, used the distributive law of scalar products, equation (17); and, in getting (70), the similar law of vector products, equation (50).

§ 117. Some spacial and motional examples may be here usefully inserted to illustrate the differentiation of vectors. Let there be any curve in space, and let s be length measured along it from some point on the curve. Also let $\mathbf{r}$ be the vector from any fixed origin O to a point P on the curve. We have then $\mathbf{r} = f(s)$. With the form of the function we have no concern.

Now, consider the meaning of the first differential coefficient $d\mathbf{r}/ds$. First, if the increment Δs is finite, say the *arc* PQ, the corresponding increment in $\Delta\mathbf{r}$ is the vector *chord* PQ, the new vector of the curve being OQ, that is $\mathbf{r}+\Delta\mathbf{r}$, instead of OP or $\mathbf{r}$. We see that $\Delta\mathbf{r}/\Delta s$ is a vector parallel to the chord, whose tensor

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is the ratio of the chord to the arc. Now reduce the increments to nothing. In the limit the direction of $d\mathbf{r}/ds$ is that of the tangent to the curve at P, and its tensor is unity, since the chord and the arc tend to equality. That is,

$$\frac{d\mathbf{r}}{ds}=\mathbf{T}=\mathbf{i}\frac{dx}{ds}+\mathbf{j}\frac{dy}{ds}+\mathbf{k}\frac{dz}{ds}, \quad . \quad . \quad . \quad . \quad (71)$$

where $\mathbf{T}$ is the unit vector tangent, and the semi-Cartesian expression (got by expanding $\mathbf{r}$) is also given. In the figure the size of $\mathbf{T}$ is quite arbitrary, since the unit of length is arbitrary.

Next, differentiate again with respect to s to obtain the second differential coefficient $d^2\mathbf{r}/ds^2$ or $d\mathbf{T}/ds$. It is the change in the unit tangent per unit step along the curve. Now, as the unit tangent cannot change its length, it can only change its direction; and, moreover, this change is a vector perpendicular to the tangent. It and the two tangents, initial and final, are in some plane, usually termed the osculating plane. It is the plane of the curve for the time being, unless it be a plane curve, when it is the plane of the whole curve. Thus $d\mathbf{T}/ds$, being at right angles to $\mathbf{T}$, points from the curve towards the centre of curvature for the time being. Moreover, its tensor measures the curvature. For the usual measure is $d\theta/ds$, where $d\theta$ is the angle between the tangents at the ends of ds, and it may be readily seen that this is the tensor of $d\mathbf{T}/ds$.

Now the reciprocal of the curvature is the radius of curvature. If then $\mathbf{R}$ be the vector from the curve to the centre of curvature C (Fig. 7), we have

$$\frac{d^2\mathbf{r}}{ds^2}=\frac{d\mathbf{T}}{ds}=\frac{1}{\mathbf{R}}, \quad . \quad . \quad . \quad . \quad . \quad (72)$$

and the vector from the origin to the centre of curvature is $\mathbf{r}+\mathbf{R}$.

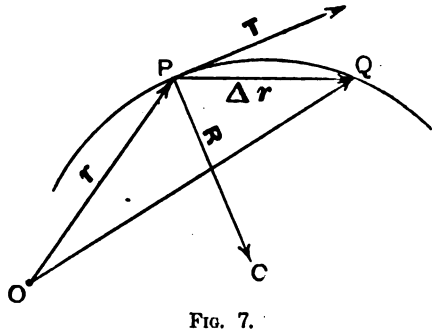

FIG. 7.

Now, referring to the same figure, let a point move along the curved path. Consider its velocity and acceleration, taking t the time for independent variable. We have

$$\frac{d\mathbf{r}}{dt}=\frac{d\mathbf{r}}{ds}\frac{ds}{dt}=v\mathbf{T}=\mathbf{v}, \quad . \quad . \quad . \quad . \quad (73)$$

by using (71), and denoting the velocity by $\mathbf{v}$. Its tensor is v or ds/dt. The interpretation of (73) is sufficiently obvious, since it says that the motion is (momentarily) along the tangent, at speed v.

Differentiate again to t. We get

$$\frac{d\mathbf{r}^2}{dt^2}=\frac{dv}{dt}\mathbf{T}+v\frac{d\mathbf{T}}{dt}. \quad . \quad . \quad . \quad . \quad (74)$$

That is, the vector rate of acceleration is exhibited as the sum of two vectors, the first being the tangential component, whose tensor equals the rate of acceleration of speed, whilst the second we may expand thus, by introducing the intermediate variable s:—

$$v\frac{d\mathbf{T}}{dt}=v\frac{d\mathbf{T}}{ds}\frac{ds}{dt}=\frac{v^2}{\mathbf{R}} \quad . \quad . \quad . \quad . \quad (75)$$

where the third form is got by using (72). This shows the rate of acceleration perpendicular to the motion. It is towards the centre of curvature, of amount v^2/R, the well known result.

§ 118. Again referring to Fig. 7, if the curve be not a plane curve, or be a tortuous curve, the osculating plane undergoes change as we pass along the curve. It turns round the tangent, and the measure of the tortuosity is the amount of turning per unit step along the curve. It is $d\phi/ds$, if $d\phi$ is the angle between the two osculating planes at the extremities of ds. It is equivalently denoted by the tensor of $d\mathbf{N}/ds$, if $\mathbf{N}$ be the unit normal to the osculating plane. This is similar to the equivalence of $d\theta/ds$ and the tensor of $d\mathbf{T}/ds$ in measuring the curvature before noticed, the equivalent plane in that case being the plane normal to $\mathbf{T}$.

The three vectors, $\mathbf{T}$, $\mathbf{N}$, and $\mathbf{R}_1$, form a unit rectangular system, for we have

$$\mathbf{N}=\mathrm{V}\mathbf{T}\mathbf{R}_1, \quad . \quad . \quad . \quad . \quad . \quad . \quad (78)$$

since $\mathbf{T}$ and $\mathbf{R}_1$ are perpendicular unit vectors. As we move along the curve this system of axes moves as a rigid body, since there is no relative change. They may, in fact, be imagined to be three perpendicular axes fixed in a rigid body moving along the curve in such a way that these axes keep always parallel to the $\mathbf{T}$, $\mathbf{R}_1$, and $\mathbf{N}$ of the curve. As it moves, the body rotates. It rotates about the $\mathbf{N}$ axis only when the curve is plane, but about the $\mathbf{T}$ axis as well when tortuous. The vector change (infinitesimal) in $\mathbf{T}$ is perpendicular to it, in the osculating plane—that is, the plane whose normal is $\mathbf{N}$, and is directed towards the centre of curvature. And the vector change (infinitesimal) in $\mathbf{N}$ is perpendicular to it, also in the osculating plane, and directed towards the centre of curvature, the vector $\mathbf{R}$ from the curve to the centre of curvature being on the intersection of the two planes mentioned.

Various expressions for the tortuosity may be obtained. Let it be Y the tensor of $\mathbf{Y}$, given by

$$\mathbf{Y}=\frac{d\mathbf{N}}{ds}=\frac{d}{ds}\mathrm{V}\mathbf{T}\mathbf{R}_1 \quad . \quad . \quad . \quad . \quad . \quad (79)$$

Then, by (78) and the context, (79) gives one expression. A second is got by performing the differentiation, giving

$$\mathbf{Y}=\mathrm{V}\frac{d\mathbf{T}}{ds}\mathbf{R}_1+\mathrm{V}\mathbf{T}\frac{d\mathbf{R}_1}{ds} \quad . \quad . \quad . \quad . \quad (80)$$

But the first term on the right is zero, by (72), the two vectors after V being parallel. So

$$\mathbf{Y}=\mathrm{V}\mathbf{T}\frac{d\mathbf{R}_1}{ds}, \quad . \quad . \quad . \quad . \quad . \quad (81)$$

gives another expression. Or

$$\mathrm{Y}=\mathrm{V}_0\mathbf{T}\frac{d\mathbf{R}_1}{ds}, \quad . \quad . \quad . \quad . \quad . \quad (82)$$

considering the tensor only. But, since $\mathbf{Y}$ is parallel to $\mathbf{R}_1$, we have $\mathbf{Y}\mathbf{R}_1=\mathrm{Y}$; therefore, by (81),

$$\mathrm{Y}=\mathbf{R}_1\mathrm{V}\mathbf{T}\frac{d\mathbf{R}_1}{ds} \quad . \quad . \quad . \quad . \quad . \quad (83)$$

is a third and entirely different expression. That $\mathbf{Y}$ is parallel to $\mathbf{R}_1$ we may prove by (79) and (81). Multiply (79) by $\mathbf{N}$. Then

$$\mathbf{Y}\mathbf{N}=\mathbf{N}\frac{d\mathbf{N}}{ds}=\tfrac{1}{2}\frac{d}{ds}\mathbf{N}^2=0,$$

since $\mathbf{N}^2=1$.

This shows $\mathbf{Y}$ is perpendicular to $\mathbf{N}$. It is also, by (81), perpendicular to $\mathbf{T}$. So its direction is that of $\mathbf{R}_1$.

By the parallelepipedal property (40) we may also write (83) thus,

$$\mathrm{Y}=-\mathbf{T}\mathrm{V}\mathbf{R}_1\frac{d\mathbf{R}_1}{ds} \quad . \quad . \quad . \quad . \quad . \quad . \quad (84)$$

Here again, we may write

$$\frac{d\mathbf{R}_1}{ds}=\frac{d\mathrm{R}}{ds\mathbf{R}}=\frac{1}{\mathbf{R}}\frac{d\mathrm{R}}{ds}+\mathrm{R}\frac{d1}{ds\mathbf{R}} \quad . \quad . \quad . \quad . \quad (85)$$

Substituting this compound vector in (84), we see that the first of the resulting vector products vanishes because $\mathbf{R}_1$ and $\mathbf{R}^{-1}$ are parallel. There is then left

$$\mathrm{Y}=-\mathbf{T}\mathrm{V}\mathbf{R}\frac{d1}{ds\mathbf{R}} \quad . \quad . \quad . \quad . \quad . \quad (86)$$

$$=-\mathrm{R}^2\mathbf{T}\mathrm{V}\frac{d\mathrm{T}d^2\mathrm{T}}{dsds^2}, \quad . \quad . \quad . \quad (87)$$

by (72), or, in terms of r and derivatives,

$$\mathrm{Y}=-\mathrm{R}^2\frac{d\mathbf{r}}{ds}\mathrm{V}\frac{d^2\mathbf{r}d^3\mathbf{r}}{ds^2ds^3}, \quad . \quad . \quad . \quad . \quad (88)$$

which is a known symmetrical form, but whose meaning is less easy to understand than several preceding expressions.

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Since, by the definition of a vector product we have $V_0\mathbf{a}_1\mathbf{b} = b$ when $\mathbf{a}_1$ and $\mathbf{b}$ are perpendicular, $\mathbf{a}_1$ being a unit and $\mathbf{b}$ any vector, we may, from the first equation (79) conclude that

$$Y = V_0 N \frac{dN}{ds}, \quad . \quad . \quad . \quad . \quad . \quad (89)$$

which is equivalent to a form given by Thomson and Tait.

Similarly, $$Y = V_0 T \frac{dN}{ds}, \quad . \quad . \quad . \quad . \quad . \quad (90)$$

Y being perpendicular to T as well as to N.

The reader may, perhaps, find the above relating to tortuosity hard to follow, though the previous matter relating to tangency, curvature, velocity, and acceleration may be sufficiently plain. The hardness lies in the intrinsic nature of tortuosity, as to which see works on analytical geometry. But the reader who wishes to get a sound working knowledge of vectors should go through the ordinary Cartesian investigations, and turn into vectors. Also, convert the above to Cartesian form through i, j, k, and verify all the results, or correct them, as the case may be. Space is too short here for much detail.

(To be continued.)

THE RECENT PARSON'S STEAM TURBINE TRIALS.

We have received a copy of an important letter which Prof. Garnett has sent to Prof. Ewing with regard to the latter's recently published report (*The Electrician*, January 8th, p. 254) on the Parsons Steam Turbine. As the question of the error caused by current lag was first raised in these columns, we have thought it worth while to print Prof. Garnett's communication *in extenso*. A difference of 5 per cent. between the true and the apparent watts is not an altogether negligible quantity, and makes the steam consumption per E.H.P. hour at full load more nearly 28·2 than 27·6lb.

[COPY.]

The Durham College of Science, Newcastle-upon-Tyne,
January 25, 1892.

MY DEAR EWING: My attention has been called to some questions which have been raised respecting the effect of retardation of currents phase upon the output of the steam turbine which you tested in Newcastle a few weeks ago. To determine the magnitude of the error thus caused, two sets of experiments were made, the former by Mr. Parsons and Mr. Stoney, the latter by Mr. Stoney and myself. In these experiments the coils used by you were compared with the water in a section of the cooling pond. The 1,000-volt armature was used, and iron pipes were thrust into the cooling pond to serve as electrodes, so that, in comparison with the 1,000 volts, the E.M.F. due to electrolysis was quite negligible, as was also any change of phase which it could produce.

In order to secure the same number of true watts as the output of the alternator, the valve which gives the intermittent steam admission was blocked open, and the steam was throttled by hand. In the second set of experiments the steam pressure at the point of admission to the cylinder was kept constant at 62lb, and the resistance was so arranged as to keep the volts the same with the coils as with the water resistance. A variation of pressure of 1lb. corresponds to about 1½ units per hour in the output. The volts being the same, and the resistance of the armature practically negligible, it follows that the speed must have been the same, and, the speed and steam pressure being the same, its steam consumption and therefore the output must have been the same, unless the steam had the intelligence to know what was going on in the external circuit and the perversity to modify its conduct for the purpose of leading us astray. The result of this test was that, with the same speed and the same steam pressure, the product of Siemens and Cardew gave 49·5 for the water and 52 for the iron, showing an error of 5 per cent. due to the lag in the iron.

In the other set of experiments the volts were kept the same, but the steam pressure, as well as the amperes, were allowed to vary, two sets of observations being made upon the coils, one with a greater and the other with a less output than in the case of the water. Repeated observations of the relation between the steam pressure and the load have enabled the law of variation of the one with the other to be accurately known, and it was, therefore, easy to interpolate between the two observations with the coils, and to determine the apparent watts which would have been registered with the coils at the pressure used in the water experiment. The result of this interpolation showed that the product of Siemens and Cardew was 4·7 per cent. greater than the true watts.

I hope that before long it will be possible to make a test of the turbine at the full working pressure of 140lb., and with a boiler of sufficient capacity to give fairly dry steam at full load. It was scarcely fair to the turbine to remove its high-pressure rings.—Very sincerely yours,

(Signed) WM. GARNETT.

To Professor J. A. Ewing, M.A., F.R.S., &c.

THE LAUFFEN-FRANKFORT TRANSMISSION EXPERIMENTS.

The *Frankfurter Zeitung*, in expressing the general wish for the speedy publication of the report on the Lauffen-Frankfort transmission experiments, remarks that the long silence of the Commission has been commented upon by adversaries of the system adopted. In the meantime, therefore, the following particulars, which have been obtained by the *Schweizerisch Bauzeitung*, from Herr Emil Huber, of the Oerlikon Works, will be read with interest.

The transmission, says the latter paper, was effected for the most part at a pressure of 16,000 volts, which was only raised towards the close of the tests to 30,000 volts. The early apprehensions that the insulators would not be able to stand this pressure have turned out to be perfectly groundless, as only one insulator, and that at the maximum pressure, was perforated by the stress. Slight breakdowns occurred also in two other instances, on one occasion through the failure of a wire, and on the other owing to the breaking of an insulator. From an examination of the broken surface of this insulator it was clear that the accident was due to a defect in manufacture, which was further corroborated by the fracture of several of them whilst they were being put up.

It is noteworthy that these defective insulators were all of the large type, with the triple oil groove, whilst not one of the small ones with the single groove (which were only used as a makeshift) was found to fail. The larger ones were made in great haste, so that slight faults might easily have escaped notice. It follows accordingly that adequate insulation for such an undertaking can be obtained by simple means and at a reasonable cost. The actual capital outlay per effective horse-power amounted to £60, of which £50 had to be devoted to the conductor.

The question is what proportion of the work absorbed at Lauffen was recovered at Frankfort. Observations were taken simultaneously at Lauffen and Frankfort. At Lauffen currents of 500, 490, and 500 amperes in the three branches were observed, whilst there were 54 volts between each of the leads and the neutral point. Leaving out of the question the phase difference between volts and current, the energy supplied amounted to 80,500 watts. At the same instant 1,060 glow lamps of 16 c.p., or their equivalent, requiring 58,000 watts, were being run off the transformers at Frankfort. This gives an efficiency of 72 per cent. Practically the efficiency must have exceeded this value, probably by about 5 per cent.

The damp weather did not seem to do any harm; no direct leakage to earth could be observed.

The static charge effects occasioned only the smallest loss. In fact, the whole undertaking showed nothing abnormal

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, January 29th (to-night).

ROYAL INSTITUTION

9 p.m. Evening Discourse. "Tales of the Scottish Peasantry." By Sir George Douglas, M.A.

SATURDAY, January 30th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "The Induction Coil and Alternate Current Transformer." By Dr. J. A. Fleming, M.A.

MONDAY, February 1st.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. II.—2. "Developments of Electrical Distribution." By Prof. George Forbes, F.R.S.

TUESDAY, February 2nd.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read: "Gold Quartz Reduction." By Alfred Harper Curtis, B.A., Assoc.M.Inst.C.E.

WEDNESDAY, February 3rd.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Extraordinary General Meeting at the Royal Institution. "Experiments with Alternate Currents of High Potential and High Frequency." By Nikola Tesla (Foreign Member).

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Dust, and how to Shut it Out." By T. Pridgin Teale, F.R.S.

THURSDAY, February 4th.

INSTITUTION OF MECHANICAL ENGINEERS.

7.30 p.m. Annual General Meeting. Election of Officers, Papers.

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SPECIAL NOTICE.

A fine Steel Plate Portrait of Prof. W. E. AYRTON, F.R.S., President of the Institution of Electrical Engineers, will be issued with the next number of "THE ELECTRICIAN."

ELECTROTECHNICS.

THE Presidential Address of Prof. AYRTON, although delivered before the Institution of Electrical Engineers, deserves the careful attention of a much wider circle, and should be studied both by those who spend money on the endowment of technical schools and colleges, and by those who spend their time as teachers in such institutions. The address will come as a pleasant surprise to some of our readers, and should be appreciated by all; for, if we may judge of the real aims and results of Prof. AYRTON'S administration, by the objects which he advocates, and the ideals which he contemplates, the Central Institution is doing a more important work than many are aware of. The title is a good one, since the Address deals with a subject that has been miscalled Technical Education. We have recently alluded to the confusion between education and instruction; and while there are many who, like Prof. HUXLEY, urge that the study of science has a high educational value, we either fail to appreciate the sense in which they use the words "science" and "education," or we must be content to differ from their views. The value of "the scientific habit of mind" is too little recognised, it is true; and we take it for granted, that, as Prof. HUXLEY has said, "the diffusion of thorough scientific education is an absolutely essential condition of industrial progress." But industrial progress is not synonymous with culture, and it is brought about by something other than education.

The recognition of the two classes into which workmen may be divided is an important feature in Prof. AYRTON'S address, and marks a liberal view which should not be lost sight of. For the mere machine-minder no "technical education is necessary;" and "his activity, if any is left him after a hard day's work, had probably better be spent in effort

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of a higher and more recreative character than would alone be necessary to make him a higher class of artisan." For him a varied course of instruction, including violin playing, modelling in clay, an ambulance class, the piano, botany, sanitary science, reading books, and other pursuits are suggested. "His general interests will be roused, the human side of his nature developed, and during the evening, at any rate, he may forget that he is the Slave of the Gramme Ring or the Slave of the Electric Lamp." Thoroughly as we agree with these opinions, we do not like the use of the words "technical education" in this extract, for it is mere instruction that is being discussed, and, curiously enough, the word "instruction" is used to include those subjects which really possess a humanising value. For the other class of workman, who has to use his brains, and on whose wits and ingenuity demands are often made, technical instruction of some sort is indispensable, and a sound knowledge of the elementary scientific principles of his work will enable him to do that work not only intelligently, but well.

Although we cannot altogether agree with the opinions expressed by Prof. HUXLEY in his address on "Science and Culture," from which we have already quoted, there are many other passages which, without being violently torn from their context, may be adduced to support our views. MATTHEW ARNOLD tells us, says Prof. HUXLEY, "that the meaning of culture is 'to know the best that has been thought and said in the world.' It is the criticism of life contained in literature. . . . . Culture certainly means something quite different from learning or technical skill. . . . . Perfect culture should supply a complete theory of life, based upon a clear knowledge alike of its possibilities and of its limitations. We may agree to all this, and yet strongly dissent from the assumption that literature alone is competent to supply this knowledge." Prof. HUXLEY goes on to advocate the introduction of physical science; but we side with Prof. AYRTON in the encouragement of those arts and humanising pursuits of which he has given examples. While a large number of our readers probably take a greater interest in physical science than in any other branch of knowledge, most of them will admit that, *in their own experience*, it has only a secondary educational value. "Higher education" is a rather vague term; it often differs not only in degree but in kind from education proper, and this difference of kind is due to the introduction of technical or scientific instruction, which has nothing in common with education, except that it is imparted by teachers to students. So far from "drawing out" and developing the human side of the human being, mere scientific study and scientific research often appear to dry up sympathy and to narrow intellectual views. We do not for a moment undervalue the immense importance of scientific or technical instruction, study, and research, but only suggest that it should not be confounded with education and culture. By recognising this distinction, specialisation, which is every day assuming greater importance as a factor of success, will no longer be unpopular.

An even greater responsibility rests with those who are engaged in training instructors than with those who are giving technical instruction to students who intend to enter the engineering profession; and it is very satisfactory to learn that the importance of practical experience at the bench is insisted on no less for instructors than for students. The business of a technical instructor is not to act schoolmaster trying to teach a trade; but to be a teacher of theory and its applications, with a practical knowledge of how those applications are made. Pure science is in the triumphant position that the range of the subject is continually increasing. The professor himself is more ignorant of the subjects which he will be teaching five years hence than the student is of the lessons which he will learn five weeks hence. The science master need never be placed in the difficulty in which the classical schoolmaster finds himself, starting boys at ten years old and letting them absorb bit by bit of grammar and syntax, translation and composition, knowing that after eight or nine years the intelligent ones will know all he has, or ever will have, to impart; and conscious that a Girton girl can cram up and pass an examination of fifth-form standard in almost as many weeks. This, not their uselessness, is the real cause of complaint against the classics.

Still more must Prof. AYRTON and those associated with him both at the Central Institution and at Finsbury, and at other establishments of the same character, rejoice that they are not subjected to the evils of "payment by results," with the attendant vices of cramming and cast-iron examination systems. We may lament that larger buildings and better equipped laboratories may be found in other countries; but nowhere are more zealous professors, painstaking demonstrators, and interested, hardworking students to be found than in those of our own institutions in which instruction is given in Electrotechnics.

INSTITUTION OF ELECTRICAL ENGINEERS.

PRESIDENTIAL ADDRESS OF PROFESSOR W. E. AYRTON, F.R.S.

Electrotechnics.

I beg to thank you for the great honour you have done me by electing me as your President for this year, a year which the need for a new complete index of this society's Journal marks out as closing the second decade of its life, a year which sees the second thousand added to our roll of members, and a year which the Electrical Exhibition at the Crystal Palace distinguishes as inaugurating the second decade of electric lighting in Great Britain.

It has gradually become the custom for your incoming President to select as the subject for his Address some investigation that has been engaging his attention. Following this custom I purpose to-night to discuss an experiment in which for the last nineteen years I have taken some part, an experiment which of all others has been the one which I have had most at heart, and that is how best to train the young electrical engineer.

To some it may appear that I am treading on well worn ground; but as the problem is one that is as yet by no means solved, and as it involves the preparation of the machine that is daily used alike by the dynamo constructor, the cable manufacturer, the central-station engineer, and the lamp maker, viz., the human machine, the problem of fashioning this tool so that it may possess sharpness, an even temper, moral strength, and a mental grain capable of taking a high polish, is one that in truth deeply concerns every member, every associate, every student of this society.

It is only fifteen years ago since I wrote from Japan to my old and valued master, Dr. Hirst, then the Principal of the Royal Naval College, Greenwich, asking whether he thought that the time had come for starting in this country a course of Applied Physics somewhat on the lines of that given at the Imperial College of Engineering in Japan. He replied that England was not yet ripe for such an innovation, an opinion which appeared to be borne out by the fact that after the authorities at University College, London, had in 1878 actually advertised for applications for a new chair of "Technology," they decided that it would be premature to take the responsibility of creating such a professorship.

But matters were advancing more rapidly than was imagined by collegiate bodies; for in that same year this most valuable report on Techical Education which I hold in my hand was issued by a committee of the Livery Companies of London, based on the opinions expressed by Sir W. (now Lord) Armstrong, Mr. G. C. T. Bartley, Colonel (now General) Donelly,

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Captain (now Sir Douglas) Galton, Professor Huxley, and Mr. (now Sir H. Truman) Wood. And although it is twelve years since this book was published I can recommend it to your notice, for it supplies most interesting reading even at the present day.

Under the guidance of the three joint honorary secretaries, Mr. John Watney, Mr. Sawyer, and Mr. (now Sir Owen) Roberts, the City and Guilds of London Institute for the Advancement of Technical Education started with a name that was very long, but in a way that was very modest, to develop a "Trades School," in accordance with this report. They borrowed some rooms, but for use in the evening only, from the Middle Class Schools in Cowper-street, Finsbury, and decided to ultimately erect a chemical laboratory in that neighbourhood. But neither the building of a physical nor even of a mechanical laboratory formed any part of the scheme for this "Local Trades School," for at that time the teaching of the practical applications of physics to industry hardly existed, and certainly not its application to any electrical industry other than telegraphy. To make a start, however, in such teaching was most desirable; and therefore Dr. Wormell, the enlightened head master of the Cowper-street Schools, consented to give up the use of some rooms, not merely during the evening, but also during the day, to enable Dr. Armstrong and myself to carry out our plan of fitting up students' laboratories with a small amount of apparatus kept permanently ready in position.

For the devotion of these rooms to the carrying out of this new experiment we must always feel grateful to Dr. Wormell, for it was necessarily accompanied by a reduction in the size of his school, and consequently by a pecuniary loss to himself.

The first laboratory course of the City and Guilds Institute was then advertised, and, on January 9th, 1880, three students presented themselves, a little boy, a grey-haired lame man, and a middle-aged workman, with emphatic but hazy notions about the electric fluid.

In order to further utilise these rooms the Institute sanctioned laboratory teaching during the day, and one of the cellars of the Cowper-street Schools was borrowed in order to fit up a gas engine, coned shafting, and a transmission dynamometer obtained out of the funds of the Institute; an A Gramme dynamo lent by Mr. Sennett, then one of the students; and two arc-light dynamos lent for transmission of power experiment by the Anglo-American Brush Corporation, whose cordial interest in the work of the City and Guilds Institute has been marked throughout. And as those dynamos were used not for electric lighting, but as laboratory instruments for educational purposes, England can claim to have been one of the first in the field of teaching electrotechnics.

Rapidly grew these electrotechnical classes; soon the temporary laboratories in Cowper-street were overcrowded, especially as applied mathematics and mechanics under Professor Perry were added to the subjects taught. The £3,000 which had been set aside for the building of this "Local Trades School" grew into £35,000, thanks to the combined donations of the Drapers' Company and of the Institute, and in 1881 was laid the foundation stone of the present Finsbury College.

During the many years that Professor Perry and I were linked together, the work of either was the work of both; but now I wish to take this opportunity of acknowledging my personal debt of gratitude for the fund of suggestion which he put forth regarding the teaching of science through its practical applications—the keynote of true technical education. The value of these suggestions you will fully appreciate, for they form the basis of those characteristic and attractive lectures which must be familiar to so many of you who have been his pupils.

As we have seen, then, the present Finsbury College grew out of the "Local Trades School," and formed no part of the original scheme of the Institute. And it was because London was really in want of practical laboratory teaching about dynamos, motors, electric lamps and engines, and because that want was supplied in a form suitable to the comprehension and to the pockets of workmen in the basement and cellars of the Cowper-street Schools, and last, but by no means least, because one of the Executive Committee of the Institute, Mr. Robins, strenuously exerted himself to further technical education in Finsbury, that the various electrical, physical and mechanical laboratories now in Leonard-street came into existence.

But the establishment of a Central Technical Institution "for training technical teachers and providing instruction for advanced students in Applied Art and Science" had been recommended in all the reports sent in to the Committee of the Livery Companies by the six authorities to whom I have referred. So that in the same year that the foundation stone of the Finsbury College was laid by the late Duke of Albany that of the Central Technical Institution was laid by the Prince of Wales.

And if you will allow me to say so, the success of the latter Institution has been no less marked than that of the former; for, in spite of the rather stiff entrance examination, the number of students who attend all four of the departments at the Central Institution is more than threefold what it was five years ago. In fact, in the mechanical and electrical engineering departments there are already about as many students under instruction as the class room and laboratory accommodation will admit. Hence this year will see a considerable increase in the amount of apparatus and machinery, as well as in the space devoted to dynamos and motors in Exhibition-road.

While on the one hand the rapid growth of the work of the Guilds Institute is no little due to the fact that the latter end of this century has ushered in the electric age of the world, the electrical industry of our country on the other hand is no little indebted to the aid so generously given by our City Companies to the teaching of electrotechnics. For the students who during the last eleven years have, for an almost nominal fee, worked in the electrical laboratories at Cowper-street, at the Finsbury College, and at the Central Institution, number several thousands; and nearly every electrical Works, every place giving electrotechnical instruction throughout this country, employs some of them.

The success which these students have thus achieved through their own ability and exertions is, I think, in no small measure due to the Institute having so wisely left the teaching it gave untrammelled by any outside examining body, so that it was possible for this teaching to be directed solely to the professional needs of the students, to be modified from time to time as it seemed necessary.

My hearty thanks are, indeed, due to the Japanese Government and the City and Guilds Institute, my masters during the last nineteen years, for having left my colleagues and myself unfettered liberty to carry on this experiment of finding out better and better ways of teaching the applications of science to industry.

And there need be no fear that with this freedom the teaching will become stereotyped, and gradually cease to deal with the living science of the factory; for, being bound by no code, we are able to vary our methods, our experiments, and our apparatus according to the continually changing conditions of the profession. In order that the Guilds Institute should fulfil its aim, it is absolutely necessary that its teaching should keep pace with industrial progress. Now, even if it were possible for outside examiners, with fixed scholastic notions, to aid in securing this result, would not their efforts be superfluous; for are there not *you*, the employers of labour, to ultimately decide whether the human tool we fashion is, or is not, adapted to your requirements?

Leaving now the consideration of the direct work of the City and Guilds Institute, including their extended system of technological examinations, at which last year 7,322 candidates were examined in 53 different subjects at 245 different places in Great Britain and the Colonies, the indirect results that have proceeded from the initiative of this Institute are even greater. For while twelve years ago education in applied science in this country was a tender little infant requiring careful watching and support, combined with constant encouragement, to-day Technical Education—with a capital T and a capital E, bear in mind—is a stalwart athlete, the strong man on the political platform, exercising the minds of County Councillors, and actually regarded as of more importance than the vested interests of the publican.

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Until quite recently it was the technical education of the young engineer that had to be considered; but now the problem has become a far wider one, for the education of the British workman is being vigorously pushed forward, and I think that it has become incumbent on you—the representatives of the electrical profession—to express your decided opinion as to what this education of the electrical artisan ought to be.

The technical education snowball, set in motion twelve years ago by the City companies, has been rolling—nay, bounding forward—so swiftly during the last year or two, that probably some of you have hardly followed it in its rapid growth both in size and speed. £30,000 has been spent on the Polytechnic in the Borough-road, the Charity Commissioners have already endowed the school with an income of £2,500 a year, and it is hoped that before the building is opened this year the income will have been doubled. £50,000 has been already promised for the Battersea Polytechnic, the Charity Commissioners having also undertaken to provide this technical school with an income of £2,500 a year as soon as the subscription reaches £60,000; and for the establishment of a Polytechnic in the City £50,000 has been set aside out of the funds of the Charity Commissioners, as well as a yearly grant of £5,350. Finally, not to speak of polytechnics in north, south, east, and west London, Mr. Quinton Hogg has himself spent over £100,000 on the Regent-street Polytechnic, while the Drapers' Company have alone given £55,000 to the technical department of the People's Palace at Mile End, and endowed it with an income of £7,000 a year; and, most recently of all, the Goldsmiths' Company have put on one side nearly a quarter of a million sterling out of their property for the land, the buildings, and for an endowment of £5,000 year in perpetuity for their Technical and Recreative Institute recently opened at New Cross.

The following table gives an idea of the sort of sums that are being spent on polytechnic education in London, but it does not profess to give the entire amounts that have been devoted to capital expenditure and yearly maintenance, even for the six Polytechnics named in the table.

CAPITAL EXPENDITURE.		YEARLY ENDOWMENTS.	
POLYTECHNIC, BOROUGH ROAD.			
Already spent	£30,000	Charity Commissioners alone (Endowment expected to be doubled before opening).	£2,500
BATTERSEA POLYTECHNIC.			
Already subscribed	50,000	Charity Commissioners alone	2,500
CITY POLYTECHNIC.			
Charity Commissioners alone to spend	50,000	Charity Commissioners alone	5,350
REGENT-STREET POLYTECHNIC.			
Spent by Mr. Quintin Hogg	100,000	Charity Commissioners alone	3,500
„ Charity Commissioners	11,750		
PEOPLE'S PALACE, MILE END.			
Given by Drapers' Company alone	55,000	Drapers' Company alone.....	7,000
		Charity Commissioners alone	3,500
Given by Charity Commissioners alone	6,750		
TECHNICAL AND RECREATIVE INSTITUTE, NEW CROSS.			
Given by Goldsmiths' Company	70,000	Goldsmiths' Company	5,000
(Representing a total expenditure at New Cross of nearly £250,000.)			
Other contributions to Polytechnics in London by Charity Commissioners	6,000	Yearly endowments of Charity Commissioners to other Technical Institutions in London...	3,200
TOTALS FROM THE ABOVE SOURCES ALONE.			
	£379,500		£32,500

Large as are these sums, they are, however, small compared with the amount raised by Mr. Goschen's beer and spirit tax, which it has been decided shall be used for the public benefit, and not for the benefit of the publican. The counties and county boroughs of England now receive nearly three-quarters of a million sterling per annum, of which the whole may be devoted to technical education. The majority of the counties and county boroughs propose to take advantage of this magnificent opportunity, and spend on technical education the entire sum allocated to them, while the remainder use at least a part for this purpose. Middlesex and London, however, stand alone, and employ their whole yearly grant of £163,000 for the relief of the rates, on the plea that they consider that the City companies are well able to look after the technical education of the metropolis.

In addition to this beer and spirit duty, 106 towns are levying rates in aid of technical education under the Technical Instruction Acts of 1889 and 1891, the number of these towns having increased by 20 in the last seven months, showing how rapidly is this desire for technical education spreading throughout Great Britain.

In addition to the large sums contributed for technical education by the City companies, collegiate bodies, and private persons who have the practical education of the nation at heart, the following represents, as far as I have been able to ascertain, the amounts that it has been already decided shall be *actually* spent *yearly* on technical education in England alone, exclusive of Scotland, Ireland and Wales:—

Received from the Customs and Excise Duties	**£500,000**
„ „ Rates	**18,046**
Given by the Charity Commissioners	**20,550**
	£538,596

The yearly amount that will be actually raised under the Technical Instruction Acts will be far larger than the £18,046 stated above, for this represents only the sums of the amounts raised in the very few towns who have already made returns.

Hence the total sum to be actually spent in England alone on so-called technical education certainly exceeds £600,000 per annum.

The teaching of electrical technology has been started in some form or other in nearly every important town in Great Britain; therefore there is no occasion for me to advocate, as I did in this room ten years ago, that a student of electrical engineering should have an education in applied science; but what I desire to most strenuously urge on you to-night is that it is your bounden duty to see that some portion of the vast sum that is about to be spent on the education of the people is used to give such a training to your workmen as shall really benefit your industry. For otherwise there is great fear that most of the money devoted to electrical teaching will either be frittered away on the natural-loadstone rubbed-amber-order of instruction so dear to the hearts of the schoolmen, or on semi-popular lectures describing in a bewilderingly sketchy fashion the whole vast field of electrical engineering.

The workmen you employ are of two classes. In the one class is the man who is all day long, say, stamping out iron discs for armature cores, and the boy who, say, feeds the screw-making machine with its proper meals of brass rod. For such work no technical education is necessary; the workers are mere adjuncts to the machines to be dispensed with as the machines become more and more perfect. Hence, unless the machine-minder has the ambition and the ability to rise to some less mechanical occupation, his activity, if any is left him after a hard day's work, had probably better be spent in effort of a lighter and more recreative character than would alone be necessary to make him a higher class of artisan.

For him the Polytechnic variety course of instruction is an inestimable blessing, for he can do a little typewriting, learn violin playing and modelling in clay, attend an ambulance class, recite a poem, and devote the remainder of his leisure to the piano, botany, sanitary science, reading books, and learning how to keep them.

His general interests will be roused, the human side of his nature developed, and during the evening, at any rate, he may forget that he is the slave of the Gramme ring or the slave of the electric lamp.

No wonder, then, that within two months of the opening of the Goldsmiths' Institute, at New Cross last autumn, 4,000 members were enrolled.

But your workman of the other class must, or at any rate ought to, think. Take for example the man engaged in wiring houses, whose work is continually changing and offering small problems to be solved. Here common sense—or uncommon sense if you prefer it—is of great value, and the work to be good *must* be

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done by a man with a knowledge of principles, and not by a mere machine-minder.

Many joints—bad joints; wires laid in cement under mosaic which cannot be replaced except at vast expense, even although the insulation has rotted away; parqueterie floors nailed to insulated wire; switch boards screwed on to damp walls; lamp holders that only make contact when the lamps are twisted askew; high-class insulated mains terminating in snake-like coils of flexible wire rubbing against metal in shop windows under shop fronts; heavy oriental metal lamps hanging from lightly insulated cord—all this would be avoided if the workmen had been taught to use their brains as well as their hands.

Now, do you think that the teaching necessary for this purpose is likely to be given at the ordinary English Polytechnic School? In the case of the Goldsmiths' Institute, the electrotechnical department has been put under the charge of Messrs. Dykes and Thornton, two diploma students of the Central Institution; and the fact that these two men are, in addition, both employed in Messrs. Siemens' Works, at Charlton, leads one to hope that their teaching, at any rate, will breathe the spirit of the factory; and, therefore, if ample funds be forthcoming for keeping the apparatus at New Cross always up to date, so that the meters, the models, the dynamos—not merely now at the start, but three years hence, six years hence—are truly representative of the industry, there will be a fair prospect that the electrical department of the Goldsmiths' Institute, although but a fraction of the whole undertaking, may really benefit the electrical workmen in the east end of London.

(To be continued.)

THE HARMONIC ANALYSIS OF TRANSFORMER CURVES.*

BY DR. J. A. FLEMING, M.A.

(Concluded from page 296.)

§ 2. **Curves of Magnetic Induction and Leakage.** — The observed curves of current and electromotive force give us the means of determining other curves which will represent the variation of the magnetic induction in the core. The induction density is not necessarily and not generally the same in all parts of the core. If, at any instant, t, b_1 and b_2 represent the number of lines of force, commonly so called, which are linked with the primary and secondary circuits respectively, and if B_1 and B_2 are the maximum values of these quantities, then B_1 and B_2 are called the total inductions through the primary and secondary circuits. B_1 has not the same value as B_2 when the secondary circuit is loaded, because some lines of force which are linked with the primary circuit escape passing through the secondary, and this constitutes the magnetic leakage of the core. It is also generally the case that the inductive density is not the same in all parts of the cross section of the iron core. Let B_1, B_2, however, be the mean value of the lines *per square centimetre* of cross section of the core. If S is the area of cross section of the iron core or magnetic circuit, and if N_1 is the number of windings of the primary coil, then $N_1 S B_1$ will be the maximum total induction in C.G.S. units enclosed by the primary or will be the maximum of the total number of lines of force linked with the primary circuit. Let b_1 be as stated, the instantaneous value of B_1. Then $N_1 S \frac{d b_1}{d t}$ will express the time rate of change of b_1 at any instant, and will, therefore, be the back-electromotive force induced at that instant in the primary circuit. Hence, by the fundamental equation

$$N_1 S \frac{d b_1}{d t} + r i_1 = e_1.$$

In which equation r stands for the ohmic resistance of the primary circuit, and i_1 and e_1 the instantaneous values of the primary current and impressed electromotive force at the same instant, when the secondary circuit is open. Therefore we have

$$\frac{d b_1}{d t} = \frac{e_1 - r i_1}{N_1 S};$$

and therefore $b_1 = \int_{b_1=0}^{b_1=b_1} \frac{e_1 - r i_1}{N_1 S} d t + \text{const.}$

where the integral is taken between proper limits. This equation shows us that if we have the curve for e_1 and the curve for i_1 we can construct a curve corresponding to $e_1 - r i_1$, and by integrating the area of this last curve between limits can obtain the value of the magnetic induction enclosed by the primary circuit at the instant corresponding to any value of e_1 and i_1. It is obvious that when $r i_1 = e_1$ then $\frac{d b_1}{d t} = o$, and hence this point corresponds to the maximum positive or negative value of the induction B_1.

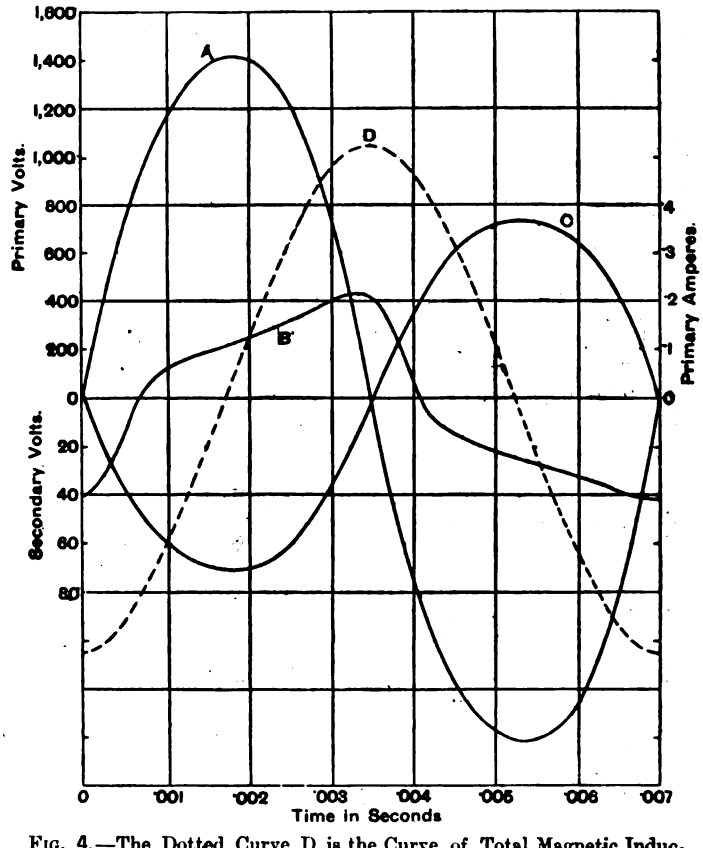

FIG. 4.—The Dotted Curve D is the Curve of Total Magnetic Induction in the Core of the 10-Light Westinghouse Transformer calculated from the Curves of Primary Electromotive Force (A) and Current (B). One scale division (vertical) = 100,000 Lines (C.G.S.) = ·001 Gauss.

Again, if B_2 stands for the average value of the magnetic induction within the secondary circuit, or for the average number of lines of force per square centimetre, which are linked with the secondary circuit, and if b_2 stands for the instantaneous value of the same, then the instantaneous value of the secondary electromotive force e_2 is

$$e_2 = N_2 S \frac{d b_2}{d t}.$$

Where N_2 is the number of secondary windings and S the cross section of the magnetic circuit, it follows that

$$b_2 = \int \frac{e_2}{N_2 S} d t + \text{const.}$$

And the instantaneous value of the induction through the secondary circuit at any instant can be obtained by integrating the curve of secondary electromotive force between proper limits (see Fig. 4). In general b_1 is not identical with b_2, and the curves of induction so formed are not similar. This is because magnetic leakage intervenes to cause the induction through the

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secondary circuit to be less than the induction through the primary circuit, that is to say, all the lines of force which are linked with the primary are not linked with the secondary circuit. The difference between b_1 and b_2 being taken, gives us the curve of magnetic leakage. In Fig. 5 the curve F, representing b_1, is so deduced from the primary electromotive force, and the curve G, representing b_2, is deduced from the curve of secondary electromotive force. The curve H represents the curve of magnetic leakage. The ordinates of the curve H are obtained by taking the difference of those of curves F and G.

The student will find it an assistance to adopt a suggestion which has already been made of giving a name to a unit of magnetic induction equal to 10^8 "lines of magnetic force." This quantity it has been proposed to call *one gauss*. The gauss, therefore, is a unit in which magnetic induction is measured. The common custom which we have hitherto followed is to employ the term *the magnetic induction* to denote that which ought properly to be called *the density of magnetic induction*. This necessitates the use of the phrase *total induction*, to denote the whole number of so-called lines of force passing through any

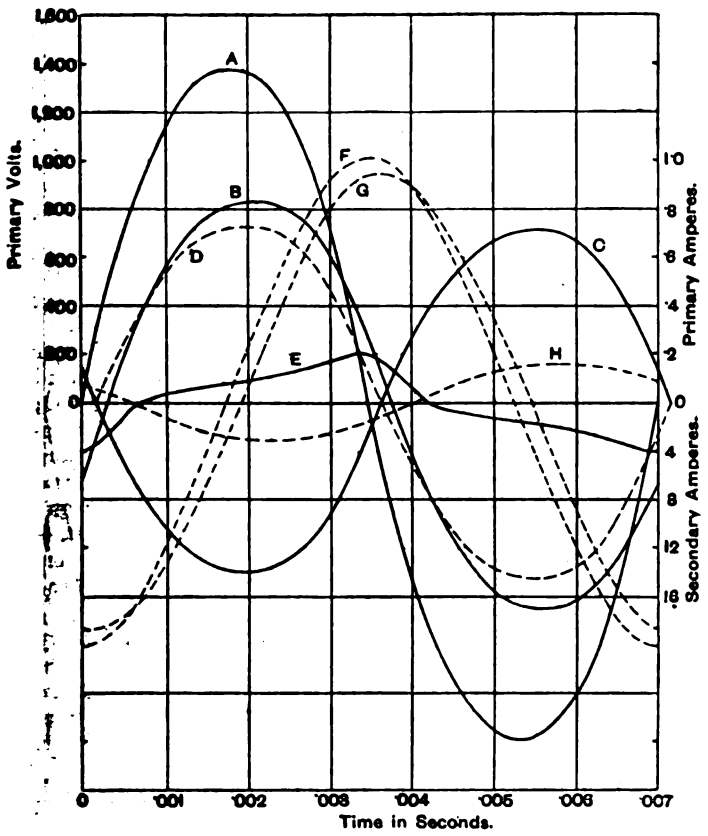

FIG. 5.—Transformer Diagram for 10-Light Westinghouse Transformer. A = Primary E.M.F. ; B = Primary Current ; F = Induction through Primary ; G = Induction through Secondary ; H = Magnetic Leakage Curve E = Magnetising Component of Primary ; C = Secondary Current.

area and to distinguish it from the number passing through a unit of area taken perpendicularly to those lines. The simplest plan is to adopt the word *gauss* as the name for a certain amount of magnetic induction or for 10^8 lines of magnetic force. We can then speak of an induction, meaning a total induction of so many *gausses*, through any area, and, if we wish to refer to the induction density, or *the* induction, at any point, we can do so by speaking of the *gausses* per square centimetre at that point. In the above equations if e and i are measured in volts and amperes, b is determined in gausses, and can always be converted to C.-G.-S. measure by multiplication by 10^8.

BOOKS, &c., RECEIVED.

"A Manual of Physics." By William Peddie, D.Sc. (London : Baillière, Tindal and Cox.)

"Oxborrow and Money-Kent's Universal Office Manual."

THE WORK OF JOSEPH HENRY.

In the New York *Electrical Engineer* for January 13th appears the first of a series of articles, entitled "America's Part in the Discovery of Magneto-Electricity—A Study of the Work of Faraday and Henry." These articles are from the pen of Miss Mary A. Henry, and form a vindication of her father's claims to the independent discovery of magneto-electricity, and other phenomena of scarcely less importance. The invaluable researches of Joseph Henry, Professor of Mathematics and Natural Philosophy at Albany Academy, are now in no danger of being overlooked ; powerful advocates of his scientific claims are not confined to the ranks of his admiring countrymen. "It detracts nothing from Henry's independent and original discovery of the law of relation between the 'electric flow' and the 'electric resistance,'" says his daughter, "that Ohm, in far distant Munich, had a theoretical dream of such a law, which, with a sagacity little short of marvellous, he reduced to a concrete mathematical formula." It does not, indeed. Many of us, however (like the political economists of old in regard to wealth), are inclined to consider fame as a fixed quantity, of which one man can only secure a fragment at the expense of another. It is to the imperishable credit of Henry that he lighted upon magneto-electricity notwithstanding multitudinous difficulties and disadvantages ; but Faraday's independent discovery of it is in no way *discredited* thereby. A priority of a few days, or it may be of a few weeks or months, is of comparatively small moment. Pure research should be the highest of intellectual pursuits, and not a mere race.

We give below a few extracts from Miss Henry's article, not because they contain any fresh evidence in support of her father's title to scientific immortality, but because they state the pathetic facts of the case concisely, clearly, and calmly :—

"There is not the shadow of a doubt, after the year 1825, that electricity can produce magnetism ; but the reverse, Can magnetism produce electricity ? With ever-deepening interest as year after year goes by, the scientific world asks this question ; but, with all the most eminent men of Europe at work upon it, nature vouchsafes no reply, and so we come down to the last days of August, 1831, and to two men, one in the Old World, the other in the New, at work upon the problem, each unconscious of the other, an ocean between them. One of these men is Michael Faraday, Professor of Chemistry in the Royal Institution of Great Britain ; the other is Joseph Henry, Professor in the Albany Academy in the State of New York. These two were destined to find the key to the problem ; the answer to the question which had baffled the world of science for half a century.

"We say the last days of August, 1831, because at that date the work of the two men nearly touch in point of time ; but the actual discovery of magneto-electricity, the reader will see, if with kind patience he will follow our story, had been made by the one—that is, Henry—at least a year earlier, namely, in August, 1830, while it was not fully accomplished by the other until some thirteen months later, namely, the 24th of September, 1831 ; for this we shall find to be the date at which Faraday first fully recognised the phenomenon, and the principle by which it is controlled.

"To understand properly the work of these two men, in reference to the discovery of magneto-electricity, it is necessary to know something of the circumstances in which they were placed. When Sir Humphry Davy was asked which he considered his greatest discovery, he answered, 'Michael Faraday.' Entering the Royal Institution in an humble capacity in 1813, the flower of his genius growing and expanding under the fostering care of Sir Humphry, Faraday had attained a high position, and an enviable scientific reputation, in the great London institution. Director of the laboratory, he was surrounded by every possible facility for the prosecution of his investigations ; and what was, perhaps, even more important, had unlimited time at his command in London, the great centre of scientific light. He was now forty years of age. Henry was nine years younger. When Faraday first entered the Royal Institution as an assistant, Henry was but thirteen. Counting the years of his age with those of the century, he

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had entered upon a course of original investigation as early as 1827; but amid such arduous duties as an instructor in the Albany Academy that, of all the twelve sisters of the year, he could only claim the month of August, the vacation time of the institution, as really his own. During four years he had been able to secure hardly more than as many months for regular scientific research. Could we look into his laboratory at this time, we would find, instead of the well-filled cabinets of the Royal Institution, only a few rude instruments, made at great expense of time and labour by his own hands. Even the material for these rude tools was often difficult to obtain. Experiments, for instance, sometimes stopped merely for the want of a scrap of zinc. We say 'could we look into his laboratory,' but we would seek in vain for a room which could properly be so called. Each series of experiments was necessarily carried on in the large hall of the Academy, which was available for Henry's use at no other time than during the summer vacation. Invariably all investigations came to a stop with the 1st of September, the beginning of the autumn session of the Academy, and were rarely resumed until the month of August came again. The invaluable stimulus of scientific intercourse and appreciation, too, was wanting. Very different was the dull commercial town of Albany from London, the intellectual metropolis of the world. A wide expanse of waters, not yet crossed by the swift ocean steamer, lay between Henry and all the culture of the Old World, and in provincial America little could be found to make good its place. Moreover, it must not be forgotten that Henry was the first who had undertaken a series of electrical experiments in America since the time of the immortal philosopher who first drew lightning from the clouds; 'the mantle of Franklin'—said Sir David Brewster—'has fallen upon his young shoulders.' Excepting Dr. Hare of Philadelphia, who was making notable improvements in galvanic apparatus, almost alone in the electric field, he stood to face the army of the Old World.

"Recalling the wide difference in condition surrounding the two, it is of no small interest now to see to what eminence each had at this time attained—the one during his eighteen years of culture and unimpeded work; the other in his few months of intermittent study, snatched at long intervals from the crowded days of four years of arduous professional labour. Constantly pursuing similar investigations, making many identical discoveries, Faraday and Henry seem like two competitors in a closely-contested race, upon whose course we have suddenly come in these August days of 1831, and with curious eyes we scan the field to see how they are running. Bence Jones says:

'If Faraday's life had ended at this time, when he finished his higher education, it might have well been called a noble success; but when we turn to the eight volumes of manuscripts of his *Experimental Researches* which he bequeathed to the Institution, we find that *his great work was just going to begin.*'

"Henry had begun his course with a series of original discoveries which might well weigh in the balance with anything Faraday had as yet accomplished, while in the particular field in which lay the '*great work*' of Faraday, which he was now '*just going to begin*' he had not only entered, but was already far ahead. The mysterious phenomena of the induction of electric currents, the reciprocal production of the magnetic and electric forces, were to him already old stories, intimately familiar, singularly well comprehended by him at this early date. He is in truth but amplifying the results which Faraday has just begun to seek, in these waning days of the summer of 1831. The younger man, as it were, had struck almost immediately into this particular path, and is now almost lost to sight in it, while the elder has only just come to the spot where his entering footsteps began.

"Let us dwell for a moment upon the importance of the answer to the great question we have been considering—the value to the world of the discovery made by these two men.

"It is not too much to say that it constitutes a veritable epoch in electrical science; upon it depend many of the most important applications of electricity to the uses of man, and new applications are developing day by day. Tyndall, the successor of Faraday in the Royal Institution, does not attempt to restrain his enthusiasm in the contemplation of it:

'I cannot help thinking,' he says, 'when I dwell upon it, that this discovery of magneto-electricity is the greatest experimental result ever obtained. It is the Mont Blanc of Faraday's own achievements. He always worked at great elevations, but higher than this he never attained.'

"Edward N. Dickerson, the eminent advocate, said of Henry:—

'The towering heights that were scaled by the daring spirit of Faraday from the East were at the same time surmounted from the West by our own countryman; both were climbing from opposite sides at the same time, and neither was conscious of the other's efforts till both stood face to face upon the summit.'

"But the standard of the West had been floating many months upon these towering heights before the standard of the East was planted. It was Henry's foot, not Faraday's, which first touched the untrodden peak.

"Let us see in what way Faraday and Henry, these two favoured children of nature, ask of her the all-important question so as to win at last a reply. Courtesy to the elder man and to the inhabitant of another country would seem to suggest that we first go over the sea to Faraday; but this may not be, for we must look among Henry's own instruments for the stepping-stone to the great discovery, made by Henry's own hands, to be a stepping-stone not only for himself but for Faraday.

"He had taken the soft iron horseshoe of Sturgeon, with its spiral of loose uninsulated wire, an infant lifting but a few pounds at an inordinate expense of battery power, and had transformed it into a giant capable of sustaining fifty times its own weight, under the stimulus of a battery of a single pair of plates of copper and zinc, scarce a hand's breadth in area. He had made two magnets—his 'intensity' magnet with a long single wire, and his 'quantity' magnet with many short wires; the latter the stronger in actual physical force, but the former endowed with the subtle capacity which enabled it to respond to the electric influence at long distances; the magnet, in fact, which made the electric telegraph a commercial possibility instead of a philosopher's plaything. He had discovered and made plain the law governing the relation between the electric flow and the electric resistances in battery and magnet; and had sent forth these children of his brain, through the pages of *Silliman's Journal*, to take their places as willing servitors in all the physical laboratories of the world. All this in the early days of this very year, in January, 1831.

"Of the theory of Ohm, now at the tongue's end of every schoolboy, but for a long time ridiculed or at least unnoticed by the scientific world, Henry in far distant America knew absolutely nothing. Five years later, in a letter written from Princeton, dated December 17, 1833, we find him asking Dr. Bache, 'Can you give me any information about the theory of Ohm? Where is it to be found?' In another letter of about the same period: 'Who is Ohm? What is his theory?' It was not until 1836, during his visit to London, that he sees at last Ohm's theory, and finds that, after all, it is in substance nothing more nor less than his own discovery, interpreted in the language of mathematical prophecy."

DEVELOPMENTS OF ELECTRICAL DISTRIBUTION.*

BY PROF. GEORGE FORBES, F.R.S.

Some eight or ten years ago the art of electrical distribution was in such an embryonic stage that electrical engineers did not even know what was the most suitable current density for their mains. The alternate-current transformer was practically unknown, but people, recognising the advantages of high-pressure distribution, were employing their brains on what was called the "multiple series" system; accumulators also were thought of, but practically the low-pressure system was the only one at the disposal of electrical engineers. Nevertheless, in spite of the strides that electrical distribution from central stations had taken since those days, no new fundamental discoveries had been made, and he (Prof. Forbes) had nothing to alter in regard to the rules he had laid down in his

* Abstract of Cantor Lecture—II. 1, delivered before the Society of Arts, Monday, January 25, 1892.

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previous Cantor lectures on the subject of electrical distribution. (*The Electrician*, October 9, 1885, *et seq.*, Vol. XV.)

Two problems which confronted the electrical engineer in 1885 confronted him still, viz., the proper size to give his mains, and how best to avoid variations of pressure at the terminals of the lamps. The current density should certainly not be greater than 500 amperes per square inch, and the variations should certainly be less than the total of 8 per cent. (+4 volts and −4 volts) at present allowed by the Board of Trade, and of which full advantage was taken by most supply companies.

So long as customers were scattered about in the manner they were at present the cost of copper must be out of all proportion. Electrical engineers should fairly face the fact that electricity must, as a rule, cost twice as much as gas, and to reduce its price they must set to work in the same scientific and determined spirit as did the early improvers of the dynamo. Several causes militated against the possibility of a cheap supply of electricity from a central station. The maximum demand was concentrated within a few hours, and largely exceeded the normal ; a central station plant was, therefore, but very partially employed, the engines worked uneconomically, fuel was wasted in heating up the boilers, &c. Indeed, at the date of his previous Cantor lectures these disadvantages figured so largely that it was a question whether the thing was commercially feasible. Many men thought it was not, and by their influence the system of granting licenses was originated to provide for cases where a few neighbours clubbed together and ran a small station of their own for private purposes. The work that had been done (of which we might well be proud), and the experience that had been gained since Major Marindin issued his memorable report on the numerous schemes for the electric lighting of the Metropolis, had caused a modification of views in this matter. Still, the fact remained that the average number of hours during which the lamps were in use was barely two hours per diem.

One result of this state of things was that clubs, restaurants, and the like, which required a steady supply of current, were somewhat unfairly charged, since they were in a manner mulcted for the short, sharp demands of other customers. If a steady demand were more general the selling price of the Board of Trade unit could be reduced to one-third of what it now was. An ordinary street arc lamp, for example, could be made a clear source of profit at £30 per annum, although, if the energy supplied were charged for at the rate of 7d. per Board of Trade unit, the annual rental would come out at £58—an instance of the difference in cost of a regular and an irregular demand. At the Athenæum Club a careful comparison had been made of the relative cost of private and public supply. The annual cost of the electric light at that club was £894 ; at 7d. per unit the annual bill would come out at £1,452.

Returning to the relative cost of electricity and gas, there was only one case in which the former was undoubtedly the cheaper, viz., in country houses. He knew of a house lighted with 210 16 c.p. lamps, and in which the lighting hours were long. The annual cost of electricity was £75, besides depreciation and the interest on an initial outlay of £1,800. Gas would have come to £300 a year.

Prof. Forbes then stated that he had circularised a large number of supply companies with a view to eliciting some information with regard to the relative masses of copper laid down as feeders and as distributing mains, &c., &c. He had, however, received but few replies—a result which was not surprising. At Kensington the mains weighed 133 tons, the feeders 15½ tons, and of the total capital of the Company 33 per cent. had been expended on mains, 43 per cent. on machinery and buildings, and 10 per cent. on secondary batteries. The Kensington and Knightsbridge Company had 12½ miles of mains. The Allgemeine Elektricitäts Gesellschaft, of Berlin, had 438 miles (700 kilometres) of main, which had absorbed no less then 1,500 tons of copper. No doubt to this lavish outlay on copper was due the excellence of this Company's supply. More money than had hitherto been usual might well be spent on copper. About one-half the total expenditure of a company might be in copper.

The three-wire system, its area of operations, practical and theoretical, and other details were next discussed. There were several methods of keeping the pressure at the lamp terminals constant ; the resistance of the feeders could be varied, a few accumulators, or a small auxiliary dynamo, might be employed to reinforce or reduce the volts, the station dynamos might be run at different voltages, and connected to appropriate feeders. The device of employing lamps of different voltage at different parts of the system was objectionable, and led to inextricable confusion. The auxiliary dynamo mode of feeder-pressure regulation was promising. Last summer he had carried out some encouraging experiments with a dynamo suitable for this purpose, namely, one built on his "non-polar" principle. It was coupled to a Parsons steam turbine running at 24,000 revolutions ; the armature was a solid bar of wrought iron 3in. in diameter ; the E.M.F. on open circuit was four volts, and on closed circuit two volts. Several large welds were effected with the current from this machine, and it ran continuously in a satisfactory manner.

The variation of 4 volts up and 4 volts down, at present allowed by the Board of Trade on a 100-volt circuit, was too much ; a variation of more than 2 per cent. was objectionable. To keep a check on the supply company serving his district, he had employed a recording voltmeter made by MM. Richard Frères, a type of instrument which should be used at the London County Council's testing stations. [Sample curves were then handed round.] At his own office in Great George-street the readings were always high during the busy hours, as it was close to the generating centre ; the variations were quite 8 per cent. At the Scottish Club in Dover-street the volts were low during the hours of maximum consumption.

After allusion to the several ways in which accumulators might be used in central-station practice, and the desirability of running the "pilot" wires to points midway between the feeding points, and not actually to them, the lecture concluded.

PHYSICAL SOCIETY.

At the meeting of this Society, on January 22nd, Prof. G. A. Fitzgerald, F.R.S., read a Paper,

"On the Driving of Electro-magnetic Vibrations by Electro-magnetic and Electrostatic Engines."

The author pointed out that as the electro-magnetic vibrations set up by Leyden jar or condenser discharges die out very rapidly it was very desirable to obtain some means whereby the vibrations could be maintained continuously. Comparing such vibrations with those of sound, he said the jar discharges were analagous to the transient sound produced by suddenly taking a cork out of a bottle. What was now required was to obtain a continuous electro-magnetic vibration analogous to the sound produced by blowing across the top of a bottle neck. In other words, some form of electric whistle or organ-pipe was required.

These considerations led him to try whether electro-magnetic vibrations could be maintained by using a discharging circuit, part of which was divided into two branches, and placing between these branches a secondary circuit tuned to respond to the primary discharge. This did not prove successful on account of there being nothing analogous to the eddies produced near an organ-pipe slit. The analogy could, he thought, be made more complete by utilising the magnetic force of the secondary to divert the primary current, first into one of the two branches and then into the other. If spark gaps be put between two adjacent ends of the branches and the main wire, then the magnetic effect of the secondary current should cause the spark to take the two possible paths alternately. Electrically driven tuning forks and vibrating spirals were cases in which magnetic forces set up vibrations ; but here the frequency depended on the properties of matter and not on electrical resonance. The frequency of delicate reeds could, however, be controlled by resonance cavities, with which they were connected, and he saw no reason why the same action could not be imitated electro-magnetically, using an electric spark as the reed.

Referring to the properties of iron in connection with electro-magnetic vibrations, he pointed out that a prism of steel one millimetre long had a period of longitudinal vibration of about one-millionth of a second, and as this was comparable with the rates of electro-magnetic vibrations the immense damping effect which iron had on such vibrations might be due to the setting up of sound vibrations in the material. Other methods of driving electro-magnetic vibrations had suggested themselves in the shape of series dynamos or alternators. The polarity of a series dynamo driving a magneto motor would, under certain circumstances, reverse periodically, and thus set up an oscillatory current in the circuit. Similar effects can be got from series dynamos charging cells or condensers. In an experiment made two weeks before, with Planté cells and a Gramme dynamo, reversals were secured every 15 seconds. Greater frequencies might be expected with condensers. The latter case he had worked out theoretically. He had also tried experiments with Leyden jars and a dynamo, but got no result. This might have been expected, for the calculated frequency was such as would prevent the currents and the magnetism penetrating more than skin-deep.

Calling the quantity of electricity on the condenser Q, the differential equation for a dynamo of inductance L and resistance r, and a condenser of capacity X, is $L\ddot{Q}+r\dot{Q}+Q/X=\dot{L}\dot{Q}$, or $L\ddot{Q}+(r-\dot{L})\dot{Q}+Q/X=0$. If $\dot{L}$ be $=0$ the solution of the equation is $Q=Q_0\epsilon^{-r/L\,t}\cos 2\pi t/T$, and the rate of degradation of amplitude depends on the factor $\epsilon^{-r/L\,t}$. If, however, $\dot{L}$ be greater than r the exponent of ϵ becomes +, and hence Q would go on increasing until limited by the saturation of the iron, or the increased resistance of the conductors due to heating.

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A dynamo without iron, provided one could run fast enough to send a current through itself, would be likely to give the desired effect. The author thought that by making such a dynamo large enough and its armature very long, it would be possible to get a frequency of about one million.

Electrostatic machines seem, however, to be more promising driving agents. Like series dynamos their polarity depends on the initial charge, and can be easily reversed. Hitherto such machines have been inefficient mainly on account of the sparking in them, but Maxwell had shown how this could be obviated. There was the same kind of difference between electro-magnetic and electrostatic machines as between Hero's engine and the modern pr engine. Like modern engines electrostatic machines worked by varying capacity, but the effect of this variation in electrostatic machines was only to vary the frequency and not the rate of degradation. From the fact that electrostatic multipliers could be driven by alternating currents, he thought they might be made to drive alternating currents. If magnetic currents could be obtained then electrostatic engines would easily be produced.

In conclusion, the author described a modified electrostatic multiplier which he believed offered a feasible solution of the problem. In this machine the collectors were supposed joined to the ends of the vibrating circuit, and would, therefore, become + and − alternately. Inductors and brushes were to be so arranged that an insulating cylinder turning between them should have many + and − charges distributed alternately round its periphery. By suitable adjustment these charges could be collected at the proper instants, so as to keep up the vibration.

DISCUSSION.

The CHAIRMAN (Prof. Lodge) said the paper was very suggestive, and full of interesting points. The subject of electro-magnetic vibrations was attracting great attention in America in connection with the manufacture of light. Hertz oscillations die out too soon to be satisfactory, for their duration rarely exceeds a thousandth part of the interval between consecutive discharges. The theory of dynamos charging condensers he considered extremely interesting, and thought the fact that the damping factor could be changed in sign must have tremendous consequences.

Dr. W. E. SUMPNER asked a question about a method of doubling frequency of alternation, recently described by Mr. Trouton, in which the armature of one alternator excites the fields of a similar machine. Mr. Trouton had said that after once doubling the frequency it was not possible to go on doing so. He (Dr. Sumpner) thought that by adding other machines the frequency could be still further increased, and gave a proof of the fact.

In reply, Prof. FITZGERALD said that adding another machine increased the frequency by a given amount, and did not double the preceding one. Hence, to increase the frequency a thousand-fold a thousand machines would be required, and on this account Mr. Trouton considered it impracticable.

Prof. S. P. THOMPSON thought the Paper very suggestive, and the acoustic analogies very interesting. Melde's apparatus was an instance of doubling or halving a frequency. On reading the title of the Paper he he had expected hearing of a method of maintaining electro magnetic vibrations by giving occasional impulses in some such way as that in which a tuning-fork could be kept vibrating by allowing the hammer of a trembling bell to knock against it. There was another method of intensifying electric oscillations, which he had seen mentioned in a patent specification by Sir W. Siemens, who suggested using a series dynamo with a telegraph cable to augment the signalling currents. On the subject of ironless dynamos he (Prof. Thompson) desired further information. Some years ago he had made calculations, and found the speed at which they would require to run was so enormous as to be beyond the range of engineering possibility.

Mr. C. V. BOYS, referring to the author's suggestion of using an electric spark with alternate paths to maintain vibration, said that he had tried whether an oscillatory spark was displaced by a magnetic field; but the displacement, even when photographed by a revolving mirror, was barely appreciable.

Prof. PERRY asked for an explanation of the term "skin-deep magnetism." He was not previously aware that Sir W. Siemens had described a method of improving cable signalling by using a series dynamo. He himself had patented a somewhat similar arrangement. He had also made a dynamo without iron, but had not got it to work.

In reply to Prof. PERRY, the author of the Paper said that in electromagnetic vibrations the magnetic force alternates so rapidly that it could not penetrate far into the field magnet of a dynamo before it is reversed; hence the magnetism would only be skin deep.

Dr. BURTON suggested that a commutator with many segments, something like that used by Mr. Gordon in his researches on specific inductive capacity, might possibly be employed for producing high frequencies.

A communication on "Supplementary Colours," by Prof. S. P. Thompson, F.R.S., was postponed.

Water Power in India.—In connection with an extensive scheme for the irrigation of the Peryar district, it is proposed to utilise the power obtainable to generate electricity for lighting the city of Madras and other cities in the Presidency.

CITY OF MELBOURNE.

The City of Melbourne are advertising for tenders for (1) Electric Light Machinery, and (2) Electric Light Cables and Insulators. We give below the specifications issued. The conditions are the same for both tenders:—

SPECIFICATION AND CONDITIONS OF CONTRACT FOR SUPPLY OF ELECTRIC LIGHT MACHINERY.

The machinery to be supplied is that set out in the schedule hereto, together with such other articles as may be supplied in accordance with the provisions of this specification and conditions of contract.

Dynamos.—To be of approved make and design, to be continuous-current, suitable for running arc and incandescent lamps in series, capable of running from 50-60 1,200 c.p. lamps, speed not to exceed 1,000 revolutions per minute. To be both mechanically and electrically well constructed, having large surface for bearings and perfect lubrication. To be fitted with regulators to maintain a constant current.

Arc Lamps.—To be of latest design and make; to run without re-carboning for sixteen hours; to be nominal 1,200 c.p., each complete with globes of clear glass.

Hanging Boards.—One to be supplied for each arc lamp; to be fitted with switch for short circuiting lamp when necessary.

Hoods.—One hood of neat and serviceable design to be supplied for each arc lamp, to which attachment can be made for suspension of lamp.

Series Incandescent Lamps.—Series incandescent lamps to be of the following c.p.'s:—20-25-32, capable of taking the current used on the arc circuit, and guaranteed for 1,000 hours burning, and so constructed that in the event of the filament breaking the current will find an easy passage through the lamp.

Series Incandescent Socket and Shade.—To be of design suitable for out-door work, including inverted tin shade and glass globe to protect the lamp from moisture and mechanical injury.

Instruments.—Ammeters to be supplied for each dynamo, capable of reading up to double the normal current of the machine; to be of approved and reliable make.

Switch Boards.—To be of suitable make for arranging circuits as desired with plug connections; to be mounted on incombustible bases.

Lightning Arresters.—Lightning arresters of approved make to be supplied for dynamo circuits.

Tenderers are to supplement the schedule hereto with any articles not mentioned therein, but which form part of or are necessary for the satisfactory working of the system of lighting proposed to be supplied.

Materials and workmanship of the best quality only to be utilised in the carrying out of the contract.

The quantities set out in the schedule are as near as can now be estimated the quantities which will probably be required, but the contractor is to supply any greater or lesser quantity which may be required at the prices set against each item in the schedule.

CONDITIONS OF CONTRACT.

Time for Completion.—The whole of the plant to be delivered f.o.b. at port of shipment in first-class order, before the expiration of ——— weeks from the delivery of notice of acceptance of tender, as provided for in conditions of tender attached hereto.

Damages for Non-Completion.—Should delivery not be given within the time specified, the contractor shall pay to the Corporation for every week or part of a week thereafter, until such delivery shall be given, the sum of £25, as and by way of liquidated damages, and not in the way of penalty, and such monies for said damages may be deducted by the Corporation out of any monies due, or that may become due, to the contractor on account of this contract.

Inspecting and Testing of Plant.—The whole of the plant must be submitted to the Inspecting Officer of the Council at the premises of the contractor, to be tested by him in such manner as he may think necessary, and particularly as to insulation, efficiency, regulation and mechanical and electrical construction, and such plant must be certified to as satisfactory by such Inspector before delivery thereof will be accepted.

Should the contractor fail to construct any portion of the machinery in accordance with the foregoing specification, either as to material or workmanship, the Inspecting Officer of the Council may at any time prior to his giving his certificate of completion of this contract reject such portion of the machinery, notwithstanding that same has previously been passed by him.

Claims for Patents.—The contractor shall at his own cost supply all such machinery free from all charges or claims with regard to royalty on any patented article, and any claims that may be made in respect to the patent rights of any articles supplied by him in accordance with this specification which may be used in connection with his scheme in executing this contract.

Delivery.—The plant to be properly packed and delivered f.o.b. at port of shipment, inclusive of all charges up till such delivery, including insurance of the plant, but not including freight.

Payment.—Payment will be made by the Council to the contractor in manner following, viz., 75 per cent. of the amount of his contract upon receipt by the Council of bill of lading for such plant, and the balance of 25 per cent. 60 days after sight of bill of lading, such balance to be in the meantime subject to any claims which the Council may have against the contractor in respect of this contract.

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Arbitration.—In the event of any dispute arising between the Council and the contractor in reference to any matter or thing connected with or arising out of this contract, such dispute shall be referred to and decided by arbitrators, one to be appointed by each party, and an umpire to be appointed by the arbitrators, and the award of such arbitrators, or any two of them, shall be final and binding upon both parties to this contract.

Interpretation Clause.—The word "Council" shall mean the Council of the city of Melbourne. "Contractor" shall mean the company, persons, or person who shall undertake the carrying out of this contract. "Inspecting officer" shall mean the person appointed by the Council for the purpose of inspecting and testing the plant contracted to be supplied. "Electrical engineer" shall mean the person for the time being holding the office of electrical engineer to the Council.

CONDITIONS OF TENDER.

Tenderers are required to submit with their tenders complete specifications and drawings of the whole of the plant which they undertake to supply, together with a complete description of their systems, and particularly showing the connections of series lamps and holders. Such specifications and drawings shall be deemed to be part of the specification of the contract. Tenderers are requested to state in their tender the time within which they undertake to give delivery, as provided in the conditions of contract. Tenders must be in the form annexed, and be signed by the tenderer with his full name and address. Within a period of three days after notice of acceptance of his tender shall have been given to him or his duly authorised agent, the successful tenderer must by himself or his agent execute a contract deed, having the specification, conditions of contract, and schedule of quantities and prices annexed thereto. Every tender must be addressed to the Right Worshipful the Mayor of Melbourne, Town Hall, Melbourne, endorsed on the outside with the name of the work to which it refers, and be enclosed in a sealed envelope. The Council shall not be bound to accept any tender.

TENDER.

TO THE RIGHT WORSHIPFUL THE MAYOR OF THE CITY OF MELBOURNE.

Under and subject to the conditions of tendering annexed hereto, ——— tender and offer to execute and perform the whole of the works and provisions, and supply all materials and labour, and everything of every kind respectively named, shown, described, and alluded to in the drawings, specifications, and conditions of contract and schedule of quantities and prices respectively, to be executed by and on the part of the contractor, for the supply of electric light machinery in conformity with the said drawings and specification, and under and subject to the conditions of contract, at the rates set out in the said schedule of quantities and prices. The total amount of this tender, calculated according to the said schedule of quantities and prices, is the sum of (£ ———). ——— hereby authorise ——— of ——— to act as ——— agent and to sign the contract hereon ——— on ——— behalf. Witness ——— hand ——— ———, this ——— day of ———, A.D. 18—.

——— Tenderer's name and address.

List of Quantities for Supply of Electric Light Machinery.

Probable quantities.	———	———
15	Dynamos, as per specifications ..... at	each
633	Arc lamps „ „ ..... „	„
500	32 c.p. series incan., as per specifictn. „	„
500	25 c.p. „ „ „ „	„
200	20 c.p. „ „ „ „	„
633	Hanging boards „ „ „	„
633	Hoods „ „ „	„
1,200	Series incandescent socket & shade, as per specification .... „	„
15	Ammeters, as per specification .. ... „	„
4	Switch boards „ „ ..... „	„
40	Lightning arresters, as per specifictn. „	„
3	Spare armatures ..... „	„
20	Sets of spare brushes ..... „	„
2	Sets of spare regulators for dynamos „	„

The whole of the articles above-mentioned to be delivered f.o.b., at ——— within the time mentioned in the foregoing conditions.

SPECIFICATION FOR SUPPLY OF ELECTRIC LIGHT CABLES AND INSULATORS.

The plant to be supplied is that set out in the schedule hereto :—

Cables.—To be of recognised good make; to be composed of seven strands of high conductivity copper wire, No. 18 S.W.G., tinned; to be insulated with vulcanised india-rubber, and braided with tarred hemp, the insulation resistance to be not less than 3,000 megohms per mile.

Insulators.—Alternative tenders are invited for the supply of insulators, viz.:

1st. To be of white porcelain of the screw bolt pattern, of a size suitable for the $\frac{7}{16}$ cable.

2nd. An oil insulator of a size suitable for the $\frac{7}{16}$ cable, of design to be submitted by tenderer.

Materials and workmanship of the best quality only to be utilised in the carrying out of the contract.

The quantities set out in the schedule are as near as can now be estimated the quantities which will probably be required, but the contractor is to supply any greater or lesser quantity which may be required at the prices set against each item in the schedule.

SCHEDULE OF QUANTITIES

For Supply of Electric Light Cables and Insulators.

Probable quantities.	———	———
160 miles	Insulated cable, as per specification, at	per mile
12,000	Screw bolt insulators „ „ „	each
12,000	Oil insulators „ „ „	„

The whole of the articles above-mentioned to be delivered f.o.b., at ———, within the time mentioned in the foregoing conditions.

LEGAL INTELLIGENCE.

The National Telephone Company v. John Milne and Sons.*

This action was again before the Sheriff, at Dundee, on Tuesday last, when

Mr. W. STILL, solicitor for the pursuer, said he had put the case on the roll in order that it might be remitted to the ordinary roll; but in the meantime he wished to state another answer to the defence of inadequate service. The pursuers sued for forehand rent or subscription. The defence related to the past year, with which they had done, and the defence was incompetent to any claim for rent or subscription for a period that had still to run. The only remedy which the defenders had seemed to be an action of damages. How did they know with regard to the period for which they were suing that the services to be rendered might not be perfect?

Mr. URQUHART objected to the case being on the ordinary roll. Though the case might be important to the Telephone Company, it was not more important to defenders than the sum of £8. 10s. There was no reason on their side why the case should be put on the ordinary roll.

Mr. STILL did not think the Company could have anticipated that any such defence was to be stated. It was a serious thing for the pursuers that in the defences of a small debt action such charges and averment should be made with reference to the Company's service.

Mr. URQUHART said it was the only defence they had. When the case was stated last Court day the Company had ample notice of the defences. There was no reason why this case should contain any question of importance. Its value was £8. 10s.

The SHERIFF: That is what it is to you; but it is not the value of the case to the Telephone Company. If all their customers were to do as defenders had done they might be ruined by the infirmities of the Small Debt Court.

Mr. URQUHART did not see why the Company should not be as subject to these infirmities as his clients. He, at all events, was willing to bide by the result of them.

The SHERIFF said the idea in sending the case to the ordinary roll was to get the matter settled as a question of principle, and to give each party the opportunity of an appeal to the Court of Session. His Lordship would let the case stand for a week so that the parties and himself might think about it. His Lordship was not, however, quite sure whether defenders had taken sufficient precautions to be able to bring a conclusive defence. It was not enough to have said that they tried to get a connection by telephone and failed. Defenders had probably only one witness to that effect for each occurrence; but in order to make a conclusive defence there ought to be two witnesses for each of the long series of connections that they tried to get, but got nothing back but profane language or some very unnecessary treatment. His Lordship did not know Mr. Urquhart would be really able to show, but he knew he did not mention any dates.

Mr. URQUHART: It would be a rather difficult thing to prove a series of specific dates. With reference to a remark by your Lordship that only one witness was available for each connection by telephone which Mr. Milne endeavoured to get, I may explain that the telephone was in the office, and what passes could be heard by the clerks sitting there; and I can prove that parties who tried to get a connection with defenders were unable to do so. If defenders had any guarantee whatever that the service was to be in any way satisfactory in the ensuing year they would be quite willing to pay the amount of this subscription.

Mr. STILL: It is a ridiculous proposition that this Company should give these subscribers a guarantee that they would have a satisfactory service for the current year. If the service proves throughout the current year not to be satisfactory, then they can have an action of damages against the Telephone Company for breach of contract.

Mr. URQUHART: The fact of the matter is that we are very anxious to have the services of the telephone in the office, and if the pursuers would agree to accept the £8. 10s. for the current year and not insist on any agreement, we will pay the amount of the current year's subscription.

After some discussion, the SHERIFF said the defenders would require to be able to tell with whom they had a connection, and the date, in order to show that the careless servants or negligent young ladies at the other extremity of the telephone either paid no attention, or, at all events, did not do their duty. Unless that were done, the Telephone Company could not tell who was the servant who did not do her duty. He thought both parties should try it for another year, and in the meantime be preparing their cases.

The case was then continued for a week.

* See *The Electrician*, January 15th, p. 282.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January* 15, 1892.

Pending Patent Litigation.—Things electrical are rather quiet just now, the principal topics of interest being the outcome of several suits that are soon to come up before the Courts, and the various rumours flying about concerning the reorganisation of the Edison Company. Several important lawsuits are now on deck, chief among them being the Incandescent Lamp Suit, which will some time this month probably be heard in the Circuit Court of Appeals, unless some unexpected legal delay intervenes. As to what will be its fate there is no one ventures a prediction. Aside from this, two other important patents are soon to be put upon the rack, one of them being the Edison feeder and main patent, concerning which two suits are now pending. This involves the general principle of feeders in electric light service; and the legal questions involved are somewhat tangled. The other bit of litigation is with respect to the Edison three-wire system, the principal parties being the Edison Company and the Thomson-Houston Company. A large amount of testimony has recently been taken with respect to the operation of the Edison three-wire system in this city, and some of the facts brought out are interesting. One of them, as has long been an open secret, is the habit of grounding the third wire in service in this city and elsewhere, for the purpose of securing economy of copper and a better balancing of the system. It is naturally objected to by the fire underwriters, and ere long the question is bound to take a serious form.

Electric Railways.—There appears at present to be an unusual amount of interest in electric traction on the part of steam railway officials, and it would not be surprising at any time to learn that electric roads of much more imposing character than any that have yet been attempted were under way. The subject is an important one, of special interest in connection with the Chicago Exposition. It is already proposed by the Illinois Central Railroad that the suburban service should be carried on by electricity, especially as strong pressure is brought to bear on the railways by the public on account of the smoke nuisance, which is becoming almost intolerable in that city. A high-speed road between Chicago and Milwaukee is also being proposed, but nothing definite has as yet been done with respect to it.

The Forthcoming Meeting of the National Electric Light Association at Buffalo.—The coming meeting of the National Electric Light Association at Buffalo, N.Y., on February 23rd, is looked forward to with a good deal of interest, and from all that can be learned it is to be a working convention, with less of the junketing and more of real business than has usually been the case. One of the questions that will come up for discussion will be the desirability of holding annual conventions. The feeling has been growing of late that an annual convention would be productive of better results than the two now held, and it is not improbable that steps will be taken to make such an arrangement the future rule of action of the Association.

Electric Block Signalling.—Electric block signalling on railroads is one of the topics that is just now before the public. The recent accident on the New York Central Railroad has stirred up an unwonted amount of comment, and steps are now being taken by the officials towards equipping their line throughout with some form of automatic signal, which would be capable of preventing a repetition of the disaster of a few weeks since. At present the road is trying three systems, the Sykes, the Electro-Pneumatic system of the Union Switch and Signal Company, and the Hall Electric Signal. They have not yet taken decisive action as to which will be adopted for the part of the main line as yet unprotected, but are investigating all the systems mentioned, especially the last, with reference to its general adoption on the line throughout to Buffalo.

CORRESPONDENCE.

GRAPHICS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your leading article on the development of practical geometry comes a little hardly upon those who have been endeavouring for years, in their humble way, to practise the very reforms which you have been so eloquently preaching.

Owing to the circumstance—the fortunate circumstance—that the Finsbury Technical College is not driven to prepare its students to pass any examinations prescribed by outside bodies, under curricula of a more or less antique character, the teaching of many subjects within its scope has developed in various directions. We may certainly claim that amongst these we make a moderate, though not an excessive, use of graphics, not only in the abstract domain of the solution of problems usually treated in the orthodox schools by analytical or algebraic methods, but in a host of more practical problems in mechanical and electrical engineering. Prof. Perry, to whose peculiar genius the mathematical course of the Technical College is indebted for many pieces of useful modernisation, has ever insisted on the value of graphic methods as affording ready means of arriving, not only at approximate solutions, but at clear understandings and mental appreciations of problems which might otherwise seem too transcendental to correspond to any actual facts. He has always advocated and practised a judicious use of graphic methods, not to the exclusion of analytical ones, but as helpful toward them, as explanatory of them, and as also of independent, because of pictorial, and, therefore, of mnemonic value. For my own part I think the latter point—to which your admirable article made no allusion—to be quite as valuable as the others. Consider the information conveyed (and when once conveyed never to be forgotten) by the shape of a curve of magnetisation, beginning at the origin, ascending slowly, then bending upward, rising almost perpendicularly, then turning over again and becoming almost horizontal. No table of figures, no algebraic formula, could ever be the instant reminder, which that curve is, of all the magnetic facts which it sums up in itself. It is so with the result of every graphic method; nay, it is so with the method itself; in carrying it out it prints itself upon the physical memory.

One great advantage to a student of the study of mechanical problems in the mechanical laboratory and electrical problems in the electrical laboratory during the same years as those in which he is studying problems in mathematics is that the former can be brought in to illustrate the latter, and make them more human and intelligible—more graspable, if I may put it so. By the study of valve gears it becomes almost an intuitive matter to see what is the proper expression for the sum of two simple harmonic functions of equal period, but differing in phase. After understanding such valve-gear problems it is a very simple matter to understand how in an alternate-current circuit the angle of lag of current must be such that its tangent is the ratio of inductance to impedance. This and the formula for the lagging current can be established simply, easily, without recourse to the solutions furnished in Boole's "Differential Equations," or to any recondite processes of integration unfamiliar except to those trained in the tricks of mathematical manipulation.

You speak of curve-tracing. Well, I have long held and urged that curve-plotting from formulæ ought to be taught at school before even quadratic equations are taught. It is a marvellous aid to algebraic work at all the stages between simple algebra and differential equations. Dr. Wormell, of the Central Foundation Schools, has long made this his practice. Would that all schoolmasters were as enlightened!

Two points, I submit, might well be urged as ripe for reform in the Schools and Universities of this country. First, the entire abolition of that hateful hybrid called Geometrical Conics; hateful because it is not geometrical, while it pretends to be; hateful because it goes about to establish, by long-winded proofs of schoolboy algebra, propositions which ought to be disposed of by a couple of lines of calculus. The

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time that is wasted over these calculus-dodging round-about proofs would have been infinitely better spent upon learning the calculus. The main use of "geometrical conics" is to divert students' time from the calculus in order to spend it upon mastering long complicated proofs which the use of the calculus would have rendered superfluous. "Geometrical conics" belongs to that order of educational ideas of which the greased pole is the best symbol. It is a device to render climbing difficult, not to help the student to climb.

The second point for which the hour for progress is at hand is the introduction of projective geometry (real geometry, not schoolboy algebra under another name) as an alternative to that grave of blighted geometrical hopes—the six books of Euclid. Personally, I am glad that I was brought up on Euclid. Not that I learned geometry from the ancient Greek. Far otherwise. What geometry was in me at that date I had already learned by compasses and ruler. Working through Euclid nearly drove out of me all geometrical ideas. But to one who has already had the advantage of learning geometry Euclid forms an excellent introduction to the science . . . . . of logic.—Yours, &c., SILVANUS P. THOMPSON.

City and Guilds Technical College, Finsbury,
January 28, 1892.

STEAM-ENGINE ECONOMY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Messrs. Parsons' letter in your last week's issue, we are sorry to think that the figures upon which Mr. Willans based his remarks and his diagrams in the discussion on Mr. Crompton's Paper should have been thought to be in any sense record figures. So far from this being the case, they were obtained from an engine which had not run very many hours. The rings had not, therefore, had time to come up to a face, and the engine was certainly not in a state to give the best possible results. It was a triple engine made for non-condensing work also, as all our engines have been up to now, and the best results could not be obtained from it, when working condensing; moreover, in plotting the diagrams illustrating Mr. Willans' remarks, an efficiency (E.H.P./I.H.P.) of 80 per cent. only was taken, as he stated at the time. This is less than we often reach with new engines, and is certainly less than is usually reached after a few weeks' work with direct-current dynamos working under the conditions which are present in electric lighting stations in this country.

At the low loads it was assumed that there were no reducing losses, which, even with the best dynamos, is not, strictly speaking, the case. The mean admission pressure in the cylinder at the highest observation taken in the condensing trial curve was 132lb. We have not a note of the pressure in the steam chest, but it would be probably some 5lb. or 6lb. higher. The figures were used for the purpose of illustrating Mr. Willans' straight line diagram, and in order to show (as was stated in his remarks) the gain which could be obtained, especially at light loads, even in the case of the very best possible non-condensing engine, by the use of a condenser. They were not intended in the case of the condensing trials to show by any means the best result obtainable. An engine which is to be used both condensing and non-condensing is at best a compromise.

The steam used in the trials was not tested at the time, but it probably contained 1 per cent. of moisture at the high loads, and was almost certainly dry, or even slightly superheated, at the lightest loads on account of throttling. The steam was taken through a separator in the ordinary way, but our trial boiler gives steam with about 2 per cent. of moisture in it, and this is not entirely removed by the separator so far as we have been able to ascertain.

Professor Ewing did not give in his report the source from which he obtained the figures quoted. The figure 18·6lb. has been several times almost exactly obtained by us; and we did not know, until he mentioned the matter to Mr. Willans, that he was quoting from the "Proceedings of the Institution of Civil Engineers." We should not have named that figure as an exceptionally good one, as we expect to do better.

In conclusion, we must heartily congratulate Messrs. Parsons on the results that they have obtained; we should not have written to the papers at all if these results had not been compared with our own.

Although we are quite sure that neither Messrs. Parsons nor Prof. Ewing had the least intention of saying anything which was not perfectly fair to us, there are many people who might make use of their report in a different manner, if we had not written as we did.

The method, we believe, adopted by Messrs. Parsons of varying the power of the engine by admitting steam intermittently is a most interesting one, and, so far as we know, it is the first time that it has been applied to a steam engine. Undoubtedly this method of reducing the power should tend in the direction of economy.—Yours, &c.,

WILLANS AND ROBINSON (LIMITED).

Picton House, Thames Ditton, Surrey, January 26, 1892. C. S. ESSEX, Secretary.

THE BOARD OF TRADE AND OVERHEAD WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In view of your short note in your issue of to-day, I think it desirable to point out a little more particularly the meaning of the phrases "Rural Sanitary District" and "Urban Sanitary District."

Under the Public Health Act, 1875, and for the purposes of that Act, England, except the Metropolis, is divided into "Urban Sanitary" and "Rural Sanitary" Districts. By sub-section 6, Urban Districts consist of Boroughs, Improvement Act Districts not being within a Borough or Local Government District, and Local Government Districts not being within a Borough or Improvement Act District. The rest of England is, under this Act, divided into Rural Districts.

The names would seem to imply that an Urban District is a thickly-populated district, and that the Rural Districts consist principally of country lanes and fields. It is so far true that an Urban District always includes the towns and more populous places, but it also always includes a great stretch of country which is nothing but lanes and fields. That this is clear will be shown by the fact that the Borough of Ipswich, being the "Urban Sanitary District" of Ipswich, includes an area which is five and a-half miles long by four miles wide.

It follows from the above that the prohibition of overhead wires in "Urban Sanitary Districts," even though they are allowed in "Rural Sanitary Districts," would have a disastrous effect, and would, in fact, prohibit any use of overhead wires save in places where no one wants to place them.—Yours, &c.,

SYDNEY MORSE.

4, Fenchurch-avenue, London, E.C., January 22, 1892.

ELECTRO-MAGNETIC VIBRATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have for some time been trying to devise arrangements by which electro magnetic vibrations might be maintained; and, following the example set by Prof. Fitzgerald at the Physical Society on Friday last, I wish to make one (the most workable) of the devices public, if you will allow me to do so in your columns, in the hope that some one who has command of the necessary apparatus may improve it, and carry out the experiments.

Imagine such a non-inductive bismuth wire spiral as is described in your issue of August 17, 1888, carrying a continuous current, to be placed in a permanent magnetic field, and to be surrounded by a solenoidal copper conductor which conveys the oscillatory current which is to be maintained. When the oscillatory current passes through the solenoid in one direction the magnetic field is increased in strength, the apparent resistance of the bismuth increases, and, consequently, the potential difference between its ends increases; and when the oscillatory current passes through the solenoid in the other direction the potential difference between the ends of the bismuth diminishes, because the magnetic field is reduced in strength. Either this increase and decrease of the potential difference between the ends of the bismuth wire or perhaps the changes in strength of the current in the bismuth wire or in some part of its circuit

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may be applied, by electrostatic or electromagnetic induction, to give helping impulses to the oscillations at the proper times. It may be found necessary to delay the impulses by transmitting them through inductances so that they may only take effect at the proper times on the oscillations which are to be maintained. It may be that the changes in the bismuth take place so slowly as to be of use in maintaining only comparatively slow oscillations.

An arrangement of this kind obviously has certain advantages. There is no spark gap in which energy is frittered away in heat, and which may affect the working of the apparatus by variations in its resistance or by getting dirty. There is no rotating part the rate of rotation of which has to be kept constant. Neither the permanent magnetic field nor the continu ous current need be kept constant in strength.

Naturally I do not see the disadvantages so distinctly, but doubtless they will be discovered.—Yours, &c.,

January 25, 1892. T. A. GARRETT.

$d\,\mathrm{M}/d\,x$.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The numerical values of $d\,\mathrm{M}/d\,x$, given on page 251, are derived from the formula on page 250, $\frac{d\,\mathrm{M}}{d\,x} = -\frac{6\pi^2\,\mathrm{A}^2\,a^2\,x}{(\mathrm{A}^2+x^2)^{\frac{5}{2}}}$ by substituting $\mathrm{A}=50$, $a=10$, and $x=0$, 10, 25, 50 successively. The only part which appears to present any difficulty is $(\mathrm{A}^2+x^2)^{\frac{5}{2}}$. To find this, "K. W. R." must first raise the quantity (A^2+x^2) to the fifth power, and then extract the square root of the resulting quantity. The calculation is, however, much simplified by the use of logarithms. The above formula only holds as long as a is small compared with A.—Yours, &c.,

Cavendish Laboratory, G. F. C. SEARLE.

Cambridge, January 26, 1892.

WHAT IS ELECTRICITY?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think you will scarcely endorse the opinion respecting this important question, stated in your issue of the 15th instant, to the effect that to attempt to answer it is to waste time.

Surely it is possible to formulate a plausible theory as to the nature of the electric "current," which shall be capable of direct experimental verification, and should this fail, the subject is certainly broad enough to admit of a second hypothesis, and, if required, of a third or fourth, which can be subjected to direct experimental test. There can be no question that a true understanding of the nature of the electric "current" lies at the root of all further advance in the production and application of energy in this form.

In your note respecting my previous letter you say I have "overlooked the fact that in the vast majority of cases the waste of energy in heating the wire is but a small part of the total energy conveyed by the current . . . . . we must . . . . . assume that the larger part of the energy is conveyed without any influence on the molecular structure of the wire."

Evidently this statement assumes the only evidence showing the electric transmission of energy to be a molecular function, to be that of the manifestation of heat. But is this so? As you remark, the waste of energy in heating is but a small part of the total energy "conveyed" by the "current." Then in what way is the larger part transmitted? If it be transmitted by ethereal wave motion, then the solid "conductor" is merely the receptacle for certain "waste" waves, which are made evident by a rise in the temperature of the wire. But take a case in which a conducting wire carries a high-tension current, but is not heated to any appreciable degree. Will it be maintained that this wire is in precisely the same state as a similar wire under normal conditions? If the energy is really transmitted by the surrounding ether, there being in this case no appreciable "waste" energy in the form of heat, it should make no appreciable difference if we substitute a glass rod for the copper wire; yet we know such a substitution would at once put an end to our "current." It seems to be very evident that, apart altogether from the heat effect, the transmission of energy by an electric current does in some way depend upon the molecular constitution of the solid conductor.

We have had all sorts of supposititious paths set forth as the lines in which the energy is supposed to travel. But no one volunteers any information as to *how* the energy is transmitted along these paths.

First we are told that the energy and current are both transmitted from the source to the work through the wire, the current being supposed to travel in one direction, the energy going in either direction, with or against the current.

Then we are told that the "current" goes by the wire, the energy traversing the surrounding medium; or both the current and energy traverse the medium, the current being to some extent under control of the wire, whilst "the energy paths," we are told, "are often very complex."

What does this mean? If the current and energy travel different paths, evidently we have two distinct phenomena to deal with. What chiefly concerns us is the transmission of energy; but if the energy travel by paths which are often very complex, what is this thing we call the "current," which is acknowledged to be more or less attached to the wire? What part is it supposed to play in the process of energy transfer?

But is it not quite as rational to assume that the state of strain, or rather the disturbance which is known to exist in the medium surrounding the wire, is an *effect* of an altered state of the wire, as it is to assume, *vice versâ*, that the disturbance in the medium is the *cause* of the altered state of the solid conductor. We do know that the solid conductor is absolutely essential to the transmission of *continuous* currents of low tension. But we have nothing to show that the presence of the ether is essential.

I have always understood that the ideal of the physicist was the reduction of all natural phenomena to the two prime factors—*matter* and *motion*. Yet the present tendency in certain quarters appears to be, not to seek the explanation of any new phenomenon by referring it to matter and motion, but to invent new properties to new ethers to suit the purpose in hand. We have already added to the list of natural phenomena one or more ethers, a presumptive *electricity* (according to some two electricities), and now we have to add one or more *energies*.

Energy used to be defined as "a capacity for doing work," but we cannot speak of the paths of a "capacity" as being very complex, or of a "capacity" travelling.

It will hardly be maintained that our knowledge of the ultimate constitution of matter is so complete as to warrant our assuming it to be impossible that matter can transmit energy in the manner to which we give the name "the electric current."—Yours, &c., WALLACE H. PAULL.

Belvedere House, Soho-road, Handsworth.

DOES ELECTRICITY EXIST?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is eleven years since I introduced to the pages of *The Electrician* (Vol. V., p. 247) the question—"What is Electricity?" Discoveries since then have made the question still more interesting. You have raised it again in a leader headed, "Does Electricity Exist?" And I observe that, like a true scientist, you have allowed correspondents to give in your columns opinions adverse to your own. It is by such friendly intercourse that the truth may be found. I therefore hope you will allow me to lay before you some facts which go far to establish that electricity does exist. When referring to the measuring of a quantity of electricity you wrote, p. 214, "We can find no corresponding mode of measuring electricity unless as the charge in a condenser. But in this case we can easily recognise that the charge may be accounted for by a displacement strain of the ether; no idea of a concrete or material substance is needed." For the sake of explanation, let it be supposed that the condenser is a Leyden jar. Then I understand you to mean that when it is charged this is accomplished by the ether straining the glass,

In Franklin's day he and his American friends discovered that there were some kinds of glass jars which could not be made into Leyden jars—because the glass would not retain a

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charge of electricity. Franklin supposed that this arose from the peculiar nature of the chemicals used in making that glass. I read the foregoing in Franklin's works in 1838, and proceeded to make experiments to discover the cause, and found that, although some kinds of glass were better than others for making Leyden jars, all kinds of glass jars, when received new from the glass works, will admit electricity to pass through them, so that they cannot retain a charge. I have had new-made glass jars which let the electricity pass through them as easily as water passes through a sieve, and yet when these same jars were kept for two three years then they made excellent Leyden jars, for they then retained electricity within them. Again, philosophical instrument makers who wish to give their customers faithful thermometers, act as follows:—They fill the tubes with mercury, seal the ends up, and allow them to lie past until the glass has become old, and then they engrave the indices. Had they done this when the thermometers were newly made the shrinkage of the glass through aging would have vitiated the indices.

With these facts before me, I cannot conceive it possible that the charging of a Leyden jar is a straining of the glass by the electricity, for the new-made glass before it has shrunk and hardened by time ought to yield to a strain more easily than the same glass when it is old and contracted by shrinkage. It is more reasonable to suppose that the atoms of electricity are of a definite size which can go through the large pores in the new-made glass, and that they cannot go through with the same freedom the smaller pores in the age-shrunken glass.—

Yours, &c.,

JAMES JOHNSTONE.

8, Merchiston Park, Edinburgh, January 25, 1892.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.

This well-known handbook for the electrical and allied trades will be published on Monday, February 8th. Orders received before the day of publication will be supplied at the subscription price of 5s., post free 5s. 9d.; orders received after that date, 7s. 6d., post free in the United Kingdom, 8s. 3d. A very large number of copies are already on order, which will take some two or three days to execute. The 1892 issue is considerably enlarged, and several important new features have been introduced, including a mass of useful financial information regarding Electrical Companies, their Officials, Capital, Dividends, Market Quotations, &c. Every effort has been made to keep the book quite up to date, and it will be found that names of new firms, alterations of addresses, &c., have been brought up to within a few days of the date of publication.

TENDERS INVITED.—Tenders are invited for the supply of electric lighting plant for the City of Melbourne, Australia. Separate tenders are required (1) for electric lighting plant, and (2) for cables and insulators, in accordance with specifications, which may be obtained (or can be seen) at the office of this journal. Tenders will be received until April 2nd next. Some further particulars will be found in our advertising columns.

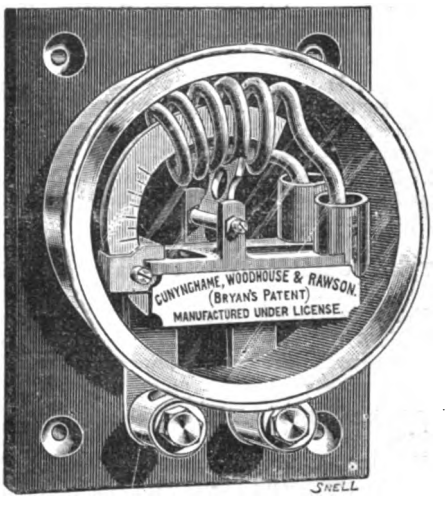
——— Our advertisement columns contain announcements that the Gas Committee of the Corporation of Manchester are prepared to receive separate tenders for the supply of dynamos for their central station in Dickinson-street, and for the supply and laying of electrical conductors and culverts therefrom. The general conditions of contract and specifications may be obtained on written application to Mr. C. Nickson, superintendent of the Gas Department, and tenders, addressed to the Chairman of the Gas Committee, must be delivered at the Gas Offices, Town Hall, not later than 10 a.m. on February 23rd.

APPOINTMENT VACANT.—The St. Pancras Vestry announce in our advertisement columns that they require an engine driver and fitter at the Regent's Park electric lighting station.

THE BRITISH ELECTRIC LIGHT COMPANY (LIMITED).—This Company, which many of our readers will remember so far back as 1878, is now reconstituted, with offices at Delahay-street, S.W. The Company undertakes all kinds of installation work for lighting or power, and has established works at Burlington-buildings, Heddon-street, London, W.

THE MARSON BATTERY.—Another primary battery is to be placed on the market. It is called the "Marson" battery, and it is claimed that the cell is specially suitable for domestic electric lighting. The negative element consists of a zinc calcium alloy immersed in dilute sulphuric acid, and the positive element of a mixture of compressed carbon, lead dioxide, &c., immersed in a solution the nature of which is not divulged beyond the fact that it consists of potassium, sodium, and bismuth salts. It is further claimed that, like the lithanode cell, if both elements are immersed in dilute sulphuric acid the cell is capable of being used as a secondary battery. As the most important part of this battery remains a secret, we have deemed it advisable not to tantalise our readers with all the details that have been communicated to us. The cell is made by the Marson Battery Company, of 29, Lloyd's-row, Clerkenwell.

IMPROVED CUNYNGHAME MAGNETIC CUT-OUT.—Messrs. Woodhouse and Rawson United are introducing a new form of magnetic cut-out in place of the well-known Cunynghame type hitherto so largely used on electric light installations in all parts of the world. The improvements consist in causing the current to pass round a pivoted solenoid, the two ends of which dip into mercury cups, this solenoid being drawn back on a fixed iron core when the current exceeds a predetermined strength. This strength may be altered by inserting more or less of the iron core into the solenoid.



This instrument has the advantage over the older type of requiring no insulation liable to combustion; it is mounted on slate or other incombustible material, no other insulation being necessary. A good feature of this instrument is the fact that the legs of the solenoid are always fully immersed in the mercury, irrespective of the current at which it is required to break circuit. The instrument is found to have a wider range than the old form, is more simple, and is said to be even more reliable.

J. D. F. ANDREWS' SYSTEM OF CONCENTRIC WIRING.—We have received a complete catalogue and price list from this firm, setting forth the virtues of the concentric system of wiring, and giving full tabular particulars as to the price of conductors, fuse-boxes, fuse-plugs, switches, wall sockets, special lampholders, tools, saddles, and other auxiliary apparatus. Messrs. Andrews' charges for wiring on their system range from 20s. to 40s per light. The absolute immunity of the concentric system from gradual short circuits is a great recommendation in many classes of installation work.

INTERNATIONAL OKONITE COMPANY (LIMITED).—The price-list of this Company is probably unique in its elaborate completeness; full particulars of every quality and class of electric conductor, from bell wire at £3. 15s. to concentric cable at £1,120 per mile, being included either in the yellow, green, salmon or pink lists. The system of colouring the pages of the different lists according to the class of conductor referred to thereon considerably facilitates the finding of the particular wire required. The lists are prefaced with some general remarks on the various manufactures of the Company, and contain the prices of wires and cables, special cables of high insulation, flexible cords and cable, and wires and cords, making in all about 60 quarto pages.

"THE MANUFACTURERS' ENGINEERING AND EXPORT JOURNAL."—We have received a copy of a new journal with the above title, which in appearance is something like a valued electrical contemporary. It contains an article on "Welding by Electricity" of much historic interest, and there are two fine still-life illustrations of the Phosphor-Bronze Company's Works, the photographs in both cases having apparently been taken during what may be called the "Influenza Era." If it were not that smoke can be observed in the dim distance, it might be conceived that the Phosphor-Bronze Company were retiring from any active concern in the trade of the country.

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PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

December 28, 1891.

22,627. S. P. HOLLINGSWORTH. London. Improvements in electric locomotives or electric motor cars.

22,636. H. H. LAKE. London. Improvements in electrical conducting wires. (V. Hannetelle, France.)

22,640. W. B. SAYERS. London. Improvements in electric arc lamps.

December 29, 1891.

22,686. E. E. ANGELL. London. Improvements in electric forges.

22,687. E. E. ANGELL. London. Improvements in electric blank heaters for forging machines.

22,695. O. IMRAY. London. Improvements in apparatus for relieving electrical circuits from static charges of electricity. (The Westinghouse Electric and Manufacturing Company, United States.)

22,708. W. HELLESEN. London. Improvements in the manufacture of porous carbon for galvanic batteries and for filters.

22,718. G. D. BURTON and E. E. ANGELL. London. Improvements in machines for treating metals by electricity.

22,720. E. E. ANGELL. London. Improved methods of and apparatus for heating metal articles by electricity.

22,725. W. H. DINGLE and J. M. URQUHART. London. A new or improved method of making and breaking electric circuits and apparatus therefor.

December 30, 1891.

22,773. C. F. ENNIS. Clapham. Improvements in and relating to electric bells and indicators.

22,782. G. C. FRICKER. London. Improvements in electric arc lamps.

22,785. L. PYKE and E. S. HARRIS. London. Improvements in the field-magnets of dynamo-electric machines.

December 31, 1891.

22,817. J. H. RIDER. Halifax. Improvements in dynamo-electric machines.

22,820. E. F. FURTADO, A. ELLIOT, and CHEETHAM-STRODE (Limited). London. Improvements in connection with telephones.

22,837. H. H. BIGLAND and J. BURNS. Liverpool. Improvements in electric arc lamps.

22,852. F. TEAGUE. London. Improvements in and relating to electric meters.

22,854. E. PLACET and BONNET. London. Improvements relating to the electrolysis of metals. (Date applied for, under Patents Act, 1883, Sec. 103, July 17, 1891, being date of application in France.)

22,855. E. PLACET and J. BONNET. London. A method of extracting chromium by the aid of electrolytic baths with a base of salts of chromium. (Date applied for, under Patents Act, 1883, Sec. 103, July 17, 1891, being date of application in France.)

22,856. E. PLACET and J. BONNET. London. A method of extracting chromium by the aid of electrolytic baths with chromic acid base. (Date applied for, under Patents Act, 1883, Sec. 103, July 17, 1891, being date of application in France.)

22,858. E. L. MAYER. London. Improvements in, or connected with, electrical measuring and indicating apparatus.

22,871. J. J. ATWOOD. London. Improvements relating to the employment of electricity when carrying out certain surgical operations.

22,872. C. W. C. RIETTI. London. Rietti system of electric tubing.

January 4, 1892.

106. W. H. STURGE. Birmingham. Improvements in electric switches.

109. A. M. ROSEBRUGH. Toronto. Improvements in telephone exchange systems.

110. R. KENNEDY. Glasgow. Improvements in generating and distributing electrical energy.

111. R. KENNEDY. Glasgow. Improvements in distributing and converting alternating electric currents, and in apparatus therefor.

152. G. G. M. HARDINGHAM. London. Improvements in vulcanising the insulating covering of electric conductors. (J. J. C. Smith, United States.)

January 5, 1892.

177. G. E. PAINTER. London. Improvements in electric drop light.

207. E. J. HOUGHTON and W. WHITE. London. An electric regulator.

January 6, 1892.

253. W. T. GOOLDEN and S. EVERSHED. London. Improvements in magnetic apparatus.

259. A. B. WOAKES. London. A method of utilising electrical energy for the heating of water and other liquids.

278. W. WHITE and E. P. P. ALLAM. London. A wall contact and plug for electrical conductors.

310. J. D. F. ANDREWS. London. Improvements in or relating to joints and attachments for concentric armoured electric conductors and the methods of making the same.

January 7, 1892.

334. H. NEHMER. London. Improved form of a dry galvanic element.

355. E. C. FURBY. London. Improvements in or relating to the electro-deposition of tin upon metals.

359. SIEMENS BROS. and Co., J. NEBEL, and W. A. COLLINGS. London. An improvement in dynamo electric machines

360. SIEMENS BROS. and Co. (Limited). London. Appliance for equalising the loads of the several conductors of rotary phase-current installations. (Messrs. Siemens and Halske, Germany.)

372. N. BENARDOS. London. Improvements in soldering, melting, and coating metals by the aid of electriciiy.

Janauary 8, 1892.

406. The AMERICAN ELEVATOR COMPANY (Incorporated). London. Improvements connected with electric motors and electric elevator apparatus. (Otis Bros. and Co., United States.)

407. E. S. D'ODIARDI. London. Improvements in liquid electrodes.

408. E. S. D'ODIARDI. London. Improvements in electro-inhalers.

409. E. S. D'ODIARDI. London. Improvements in the electric static sprays.

410. E. S. D'ODIARDI. London. Improvements in pneumo dynamometers.

411. E. S. D'ODIARDI. London. Magneto voltaic electrode.

416. H. CAPELLE. London. An improved process for manufacturing galvanotypes. [Date applied for under Patents Act, 1883, Sec. 103, June 9, 1891, being date of application in France.]

January 9, 1892.

475. J. SWINBURNE. Teddington. Improvements in apparatus for testing insulation electric meters and alternating-current motors

486. R. E. B. CROMPTON. London. Improved variable resistances for electrical purposss.

SPECIFICATIONS PUBLISHED.

1890.

20,838. BIRKBECK. (Henrichsen.) Dry element for electrical purposes. (Price 6d.)

21,031. DAVIES. Secondary batteries, (Price 1s. 6d.)

1891.

1,046. GOULD and GOTTSCHALK. Prepaid telephonic messages. (Price 8d.

1,251. ATKINS (E. and W.) Electrical switches. (Price 8d.)

1,639. SWINBURNE. Condensers for electric currents. (Price 4 l.)

1,680. TAVERNIER. Transmitting electric currents. (Price 8d.)

2,068. SIEMENS BROTHERS AND CO. (Siemens and Halske.) Semaphore signal apparatus. (Price 8d.)

3,239. RAWORTH and others. Electric conduits. (Price 6d.)

3,383. KINGDON. Dynamo-electric machines. (Price 8d.)

3,592. WHITEHEAD. Electric alarm apparatus. (Price 6d.)

4,554. REDFERN. (Lahmeyer and Co.) Armatures for electrical machinery. (Price 8d.)

4,579. BINSWANGER and SMEETON. Electric cigar lighters, &c. (Price 6d.)

14,796. ABEL. (La Compagnie AnonymeContinentale pour la Fabrication des Compteus à Gaz et autres Appareils.) Electric meters. (Price 8d.)

15,937. FELL (Weston). Electrical measuring instruments. (Price 6d.)

16,388. HAYS. Arc lamps. (Price 6d.)

19,900. THOMPSON. (Coffin.) Welding metals electrically. (Price 6d.)

19,901. THOMPSON. (Coffin.) Welding metals electrically. (Price 6d.)

20,257. THOMPSON. (La Compagnie de l'Industrie Electrique.) Electric lamps. (Price 6d.)

COMPANIES' MEETINGS & REPORTS.

The St. James's and Pall Mall Electric Light Company (Limited).

The ordinary meeting of the shareholders of this Company was held at St. James's Hall Restaurant, Piccadilly, on Tuesday last, Mr. Eustace J. A. Balfour presiding. The General Manager and Secretary (Mr. Frederic J. Walker) read the notice calling the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: The next business is to move that the report and accounts ended December 31, 1891, as submitted by the Directors, be received and adopted, and that the dividend recommended therein be declared payable on February 1st.

Mr. LATIMER CLARK seconded the motion.

The CHAIRMAN: I do not think it is very necessary for me to go in great detail into the working of the Company during the past year, because this report is very full, and I think on the whole gives as much information as it is desirable should be placed in the hands of the public The most important event perhaps of the year was the raising of £100,000 of additional capital in the form of Preference shares for the completion of

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the northern station. The last £50,000 were largely over-subscribed and at a premium of 30s., a fact which, I think, shows that both the shareholders and the public in general show great confidence in the soundness of the business of the Company. This sum of £100,000 will, as you are aware, be chiefly devoted, and partly has been devoted, to the purchase of the site for and the erection of our northern station, and we expect this station, when erected, will probably be the best of its kind in the world, as it will contain all the cumulative experience that we have gained in the erection of our present station as well as all that of other companies gained in similar work. Machinery sufficient to furnish about 20,000 eight-candle lamps, is already nearly completed, and will be placed in position as soon as the building is ready to receive it. It may be of interest to the shareholders to know that a large part of this machinery was running and supplying light at the Naval Exhibition. It has been running up to this time without hitch or flaw, and we took it over not as new and experimental material, but as having been tried and found satisfactory. The great feature in the system which we are now developing is what we call the great trunk main, which is already partially made, and will connect the northern station with the existing station in Mason's-yard. It has a section of 8 square inches—probably the largest main ever made, and it is capable of carrying a current sufficient to supply 25,000 lamps. The importance of this cannot be over-estimated, because, well as our present station has worked up to the present time, and well as we expect it to work, it is impossible that it may not be necessary to carry out repairs in it which may involve its being shut down for a short time. When the main has been constructed, and when the Northern station is in working order, we shall be in a position in the slack months of the year to shut down one station or the other for any repairs that may be desirable, and to work entirely from the one that is not shut down. An eminent electrician, connected with electric lighting, told me some months ago that all new electric light stations should be supplied with two chimney shafts. Whether he is right or not in his opinion I do not venture to say, but the system that we propose to adopt combines all the advantages of his proposal, and a considerable number of other advantages besides, in addition to being much more economical. I do not think I need say any more on the particular subject of the working of the Company during the past year; but I should like before I sit down to touch on a matter which I regard as of very great importance, not only to this Company, but to all electric lighting companies, and to the whole question of the electric lighting of the metropolis—I refer to the legislation under which we have obtained our Provisional Order. When, first of all, legislation was started in respect of electric lighting, the term fixed for the expiration of a licence was seven years—that is to say, that the licence could be terminated by the local authority or by the Board of Trade after seven years. This legislation seems to have been based under a sort of morbid terror that electric lighting companies were going to become enormous corporations, with great powers of monopoly. The Provisional Order under the same Act was limited to 21 years. The result of this extraordinary Act was that everybody who had invested their money in electric lighting concerns lost it, and that the public was kept out of the electric light for several years, London being left far behind other European cities and many towns and villages in America. Under the present Act, each Provisional Order lasts for 42 years, but all Provisional Orders are subject to two conditions—first, that the Board of Trade can revise rates at the end of seven years; that is to say, the Board of Trade can step in and say, "You are charging too much:" and second, that that body has arranged to put into every parish, district, or area in London at least two electric light companies. Now, if you will consider these points for a moment I think you will see that they act first of all against the consumer and directly also against the electric lighting companies. As we have only a terminable lease of life—42 years—it is absolutely necessary for us to put by what we have termed a redemption fund, calculated to be sufficient to replace the deficit in the capital account which we anticipate at the end of 42 years, when we shall be or may be obliged to hand over our business at a valuation by the local authority who has the option of purchasing. If our tenure were permanent, after paying to our shareholders a reasonable dividend, we should use the amount of this redemption fund in reducing the cost of the light, and in the present year we made a rough calculation even if we paid to our present shareholders the same dividend we propose to pay, I think we should have been able to reduce the cost of the light to the consumers about 1d. out of every 7d. Secondly, the power of septennial revision introduced an element of uncertainty to the business which must be injurious to all interests concerned. Nor is it likely that this revision can be made to work in a practical manner. Had the Board of Trade seen fit to grant complete monopolies in every district—that is to say, one company in each district—subject to some scheme of revision on a previously defined scale, such a system might have been found to be satisfactory; but as it is, on what basis are they going to revise? Supposing we have in one district, or any parish in London, the case of two companies, one of which has paid on an average for seven years a dividend of 20 per cent, and the other has paid during the same period a dividend of 2 per cent., is the Board of Trade going to insist upon the reduction of the cost of electric lighting because one company is paying and the other is not? In that case you would find the shareholders in one company absolutely ruined; in fact, they cannot get out of this, they must be either fair or unfair to one of the companies, or unfair to the consumer's district. In fact, I may say that the two systems which they have adopted of what they term limited competition and a system of revision of rates are absolutely inconsistent. Now, lastly, the system of limited competition is injurious alike to consumer and producer in that it makes it necessary to earn a dividend on a much larger capital than would be necessary to supply that district. Supposing you have two electric light stations, and two sets of mains in one district instead of one, the dividends have to be earned on a capital, which I think, I am not overstating in saying is at least twice what it ought to be. You have, in addition to that, the disadvantage that the streets are twice cut up, and we have also to consider that the initial expenses of the Company have to be twice gone over; and these are items which are very much larger than those who are not in the business are apt to think. I do not think I have anything more to say, but I shall be glad to answer any questions that may be put to me.

Colonel FRANCIS said he wished to put a few questions. Referring to paragraph 7 in the report, in which the net earnings of the Company during the past year were stated to be £10,395, he maintained that the net earnings had been £15,409, and that part of the law charges—£558—included some of the expenses incurred in 1890, and therefore ought not to come out of revenue in 1891. He had added to the net earnings, as stated in paragraph 7, the total amount of the depreciation fund and the redemption fund. His reason was as follows:—He found that a very large sum—£1,702—had been charged during the year to the repair of machinery. When a Director of the Company he consulted the makers of their machinery and they informed him that if the machinery were kept in perfect repair the depreciation was very slight. He did not say that there was no depreciation; but he said that the sum of 5 per cent. on the outlay for the machinery would be ample for the purpose. At any rate, he asked on what calculation the enormous sum of £4,013 had been arrived at after £1,702 had been spent. Seeing that the last meeting he attended was a painful one, he wished to know the grounds on which the Directors said that there would be a loss of capital on the expiration of the term covered by the Provisional Order. Turning to capital account, he found that the sum of £20,297 was paid for the new site. They must remember that Mason's yard cost £9,500, and that a site within 50 yards of the present new site was open to purchase by the Company whilst he was a Director, for £1,100 and £100 a year. He had had the site valued by the most experienced surveyor of the parish, who placed its value at £8,000. The offices of the St. James's Company were small in size, and, as far as he had observed them, plain in appearance. There were three small rooms on which the Directors had managed to spend £700 in furniture. The machinery and plant stood at £12,000, and he wished to ask whether that machinery was at the new station, or had it been supplied to the original one? Could not the capital account of the two stations be kept separate so that they might know exactly what each one cost? What sum was to be paid for building the new station? £100,000 had been obtained from shareholders for preference shares, bearing interest at the rate of 7 per cent. At the time that this was proposed there was a strong opposition, for it was perfectly well known that the money could be raised at 5 per cent. In fact, an offer of £50,000 had been made to the Directors, and spoken of at the last meeting. It was urged that if the sum was large, at any rate the original shareholders would benefit by the transaction. The original holders did benefit by the transaction, which was made in their interest. He thought it was absolutely necessary that the shareholders should obtain information as to what was going on more than once a year. £350 was spent on printing and advertising, but he had never seen an advertisement in connection with the Company; and he had received no information of what was going on since last meeting. The questions he would like to ask were: On what scale had the Directors gone in forming an estimate of the depreciation of the machinery? Had the whole of the sum of £558 become due for law charges in 1891? On what grounds did the Directors represent that there would be loss of capital on the expiration of the term covered by the general order? What course did the Directors intend to pursue in relation to their fees? Did they intend to replace "not to exceed £1,500" in the paragraph in the Articles of Association bearing on this matter? As the printing was charged at the rate of £350 a year, would the Directors see that a full report of this and succeeding meetings be sent to each shareholder? Would the Directors further arrange that the meetings should be held in January and July? What was the cost of the new site, and who was the vendor who held the property? What surveyor, acting on behalf of the Company, recommended that price to be paid, and what sum was to be paid under the contract for building the new station?

Mr. H. J. MUIRHEAD thought that had they held their meeting in the City they would not probably have been deprived of the presence of two of their Directors. He did not think that the accounts were an exhibition of economy in the management of their affairs. To begin with, not only did they put down £1,700 for maintenance and renewals, but there was an enormous amount of £4,000 for depreciation, so that at least £7,000 was put against depreciation. He presumed that this Company was governed by section 2 of the Electric Act, 1882, and in that case it was provided that if the Company were taken over by the Local Authority the price paid would be the fair market value at the time of purchase. He observed that £1,000 accumulative a year at compound interest came to 75 per cent.; consequently, they ought to have £75,000 at the rate of 3 per cent., and £95,000 at 4 per cent. He thought that the Chairman must agree that the sum would be totally beyond the requirements of the case. He thought that £558 was an enormous sum for legal expenses, especially as he understood they were in connection with an arbitration case which the Company had won, and the other side would have had to pay. The Chairman had stated the case fairly respecting the Board of Trade, against which body there was no use knocking their heads.

The CHAIRMAN, in reply, said that the scale on which they had based their estimate of depreciation was the ordinary one used in businesses of the kind. On the face of the accounts it was not the case that the whole of the £558 had become due for law charges in 1891. It was a perfectly notorious fact that there would be a loss of capital at the expiration of the term of the general order. The Directors had discussed the matter, and that was their view. As to the course the Directors were to pursue in respect of their fees, an answer to the question had been given to Mr. Muirhead in 1891 in special meeting. The Directors had no such intention as to replace the words "not to exceed £1,500" in

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the Articles. Their printing was at the rate of £350 a year. The Directors hesitated to send a report of their proceedings to shareholders, having regard to the expense. They would consider it, as well as the question of having half-yearly meetings. The surveyor of the Company was Mr. Wilkinson, and the price paid for the site was £20,000. The contract for building the new station was £19,000, He could not say at that moment what amount had been spent on plant and machinery. It was much too early to say whether the accounts of the two stations could be kept separately. The accounts were kept under Board of Trade rules. The only reason why they had met there was that they were within their own boundaries, and they were patronising a good customer.

The resolution was then carried.

The CHAIRMAN then moved the re-election of Mr. Egerton H. Clarke and Mr. H. Woodburn Kirby to their seats at the Board.

Mr. HOMAN asked that the names might be put separately.

The CHAIRMAN thereupon moved the re-election of Mr. Clarke.

The motion having been seconded by Mr. Darnton Hutton,

Mr. HOMAN moved as an amendment that he be not re-elected, principally on the ground that Mr. Clarke had sold on the Stock Exchange a founders' share for £350, and, having done so, went to the meeting of the Board at which the dividend was to be decided.

Mr. H. J. MUIRHEAD seconded the amendment. There were certain things in connection with the Company which could not bear the light of day, and they ought to get Mr. Clarke's explanation of his conduct.

The CHAIRMAN said he was extremely sorry that Mr. Clarke was not present, and that such an unpleasant incident had arisen. But Mr. Clarke, when he went to the meeting referred to, did not know what their decision would be.

The amendment, on being put, was declared carried.

The CHAIRMAN then announced that the Board demanded a poll, and appointed that day week, from three to four p.m., on which to take it.

Mr. Homan and the Auditor were appointed scrutineers.

On the motion of the CHAIRMAN, seconded by a SHAREHOLDER, Mr. Kirby was then re-elected to his seat at the Board.

The auditors, Messrs. Deloittes, Dever, Griffiths, and Co. were reappointed, on the motion of a SHAREHOLDER, seconded by Mr. MUIRHEAD; and a vote of thanks having been accorded to the Chairman for presiding, for which he briefly expressed his acknowledgments, the proceedings were brought to a close by passing a vote of thanks to the General Manager and Secretary, the chief engineer, and the staff.

J. E. H. Gordon and Co. (Limited).

The second annual general meeting of this Company was held on Monday last, at the offices of the Company, at 11, Pall-mall; Mr. J. E. H. Gordon, M.Inst.C.E., Chairman of the Company, presiding.

We have received from the Company the following particulars:—

The SECRETARY (Mr. Henry Sinclair) read the notices convening the meeting, and the minutes of the previous meeting were confirmed.

The report of the Directors and statement of accounts were taken as read, and the CHAIRMAN explained that the year had been one of increasing and satisfactory business; the turnover for the second six months of 1891 having been more than double that of the first six months. He further stated that among the numerous important works that have been carried out during the year were the electric lighting of Carlow (described in *The Electrician*, July 24, 1891) and Larne in Ireland, and the erection of the large central station for the Crystal Palace District Electric Supply Company, which is now supplying the greater portion of the electricity in use at the Electrical Exhibition at the Crystal Palace. He was able also to announce that arrangements have been made for adding to the electric lighting department, a department to deal with the important problem of electric traction.

A dividend of 30 per cent. for the year was declared, and Mr. W. J. RIVINGTON (Managing Director) proposed the adoption of the report and accounts, which was seconded by Mr. S. W. SEARLE, and agreed to unanimously without discussion.

The proceedings then terminated.

In reference to the meeting of Messrs. J. E. H. Gordon and Co. (Limited), given above, it may be of interest to give the last statutory return of the Company lodged at Somerset House:—

J. E. H. GORDON AND CO. (LIMITED).—The statutory return of the above-named Company, made up to January 31, 1891, was filed on October 28, 1891. The Company was registered on September 19, 1890, with a nominal capital of £50,000, in £10 shares, to acquire and take over as a going concern the business of J. E. H. Gordon, electrical engineer, and to carry on the business of electrical engineers, and the business of constructing, manufacturing, supplying, and maintaining electric light machinery and apparatus. An agreement, made September 15, 1890, between J. E. H. Gordon and W. J. Rivington of the one part, and H. Sinclair of the other part, fixes the purchase price of the above-named business at £30,000, to be fully satisfied by the allotment of 2,000 £10 shares to J. E. H. Gordon or his nominees, and the allotment of 1,000 £10 shares to W. J. Rivington or his nominees, provided that the said W. J. Rivington applied for and accepted 200 £10 shares, and paid the full amount for such shares immediatly upon the incorporation of the Company. At the date of making up, 3,205 shares had been taken up, of which 3,000 had been issued as fully paid. Upon the remaining 205 the full amount had been called, resulting in the payment of £2,000, leaving £50 in arrears. The principal subscribers are James E. H. Gordon, of 1, Queen's Gate-gardens, S.W. (2,000), and W. J. Rivington, of 21, Gledhow-gardens, South Kensington, S.W. (1,200), the remaining five shareholders taking one share each. Registered office: 11, Pall-mall, London, S.W.

City and South London Railway Company (Limited),

The following is the report of the Directors, to be submitted to the half-yearly ordinary general meeting, to be held at Winchester House, Old Broad-street, London, E.C., on Tuesday next, February 2nd, at 12 noon:—

The receipts during the half-year from all sources amounted to £20,243. 15s. 4d., and the cost of working for that period to £15,516. 9s. 8d., leaving a net profit of £4,727. 5s. 8d. Including the amount brought forward from last half-year, the net revenue account shows a balance of £5,326. 0s. 9d.; of this amount the Debenture interest absorbs £4,304. 10s. 0d., leaving a balance available for dividend of £1,021. 10s. 9d., out of which it is recommended that the full dividend of 5 per cent. be paid on the Perpetual Preference shares; and although the balance remaining would allow of a very small dividend on the Ordinary shares, it is recommended that it be carried forward to the next account.

The number of passengers carried by the railway in the past half-year was 2,749,058, showing an increase over the previous six months of 336,712, making the aggregate number carried since the opening of the line 5,349,580.

Your Directors have, after mature consideration, found it necessary to vary the fares at certain stations between stated hours, with a result advantageous to the Company and to the comfort of the travelling public. To meet the convenience of residents along the line, a system of season tickets has been in operation since the 1st November last.

Notwithstanding a considerable increase in the rates and taxes and other items over which your Directors have no control, they have satisfaction in reporting that the total expenditure shows a small decrease over that of the previous half-year, and it is hoped that some further reductions may still be made.

The rolling stock has recently been increased by the addition of the two new locomotives referred to in the last report, which it is hoped will give greater power and speed in working the trains, and the six additional carriages have also been delivered. The fourth engine and dynamo are now in course of erection for the generating station.

During the past three months the traffic of the railway has shown a marked and satisfactory increase, which there is every reason to hope will continue and be still further augmented. To meet this growing traffic arrangements are in progress for providing a more frequent train service during the busiest hours of the day. After the experience of the past year there is every reason to be satisfied with the use of electricity as a motive power for the working of this railway, and for a confident belief that when all the details are fully perfected it will be found to be at once safe, convenient, and economical.

The difficulties which have been experienced in dealing with the increasing traffic at the King William-street Station, owing to its confined dimensions and the steep incline leading to it, have induced your Directors to deposit a Bill by which they seek Parliamentary powers to make a foot subway connecting the terminus of the London, Brighton, and South Coast Railway Company at London Bridge with the station already authorised to be constructed at the corner of Denman-street, and also to construct two additional tunnels under the river with easy inclines to a central station at the corner of Lombard-street, and thence under Moorgate-street to the Angel at Islington, where ample siding room can be obtained at a small cost. These proposals meet with the approval of the Directors of the London, Brighton, and South Coast Railway, and will bring upon the line a very large and profitable traffic, and at the same time reduce considerably the cost of working the existing railway. It is also proposed to construct an inclined footway connection between this Company's station and the Monument Station of the Metropolitan and the Metropolitan District Railways, and powers for that purpose are included in the Bill. The Bill will be submitted for your approval at the conclusion of the half-yearly meeting.

Owing to other engagements, Mr. Alexander Hubbard has resigned his seat at the Board, and the vacancy thus caused has been filled by the election of Mr. Edwin Tate, of 21, Mincing-lane, London. The Director retiring is Mr. Charles Grey Mott, who is eligible for re-election. The auditors retire and are also eligible for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

JACQUARD AUTOMATIC READING AND PUNCHING MACHINE SYNDICATE (LIMITED).—This Company was registered on January 21, 1892, with a capital of £150,000 in £1 shares, by Hays, Schmettau and Co., 31, Abchurch-lane, London, E.C. The objects are (*inter alia*) to carry on the business of an electric light company in all its branches; to construct, lay down, establish, fix, and carry out all necessary cables, wires, lines, accumulators, lamps, and works; to generate, accumulate, distribute, and supply electricity; and to carry on the business of electricians, electrical contractors, electrical and mechanical engineers, and suppliers of electricity for the purposes of light, heat, sound, power, or otherwise; and of manufacturers of and dealers in all apparatus required for or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. Solicitors: Arthur T. Ashwell, Nottingham; and Hays, Schmettau, and Co., of 31, Abchurch-lane, E.C.

JOHN LONGBOTTOM AND CO. (LIMITED).—This Company was registered on January 15, 1892, with a capital of £2,000, in £10 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are to carry on the business of machine and engineers' tool makers, makers of power looms and other machinery, millwrights, mechanical and electrical engineers, iron and brass founders, workers out of mechanical inventions, &c.

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MAYBURY AND MARSTON (LIMITED).—This Company was registered on January 25, 1892, with a capital of £50,000, in £5 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are to acquire and carry on the business of iron and steel manufacturers, mechanical and electrical engineers, tool makers, iron and brass founders, &c., carried on by Edward Maybury and Edward Marston at the Perseverance Iron and Steel Works, Brindle Heath, Pendleton, near Manchester, and at Huyton Quay, near Liverpool, under the style or firm of "Maybury and Marston." Registered office: The Perseverance Iron Works, Pendleton, near Manchester.

READING ELECTRIC SUPPLY COMPANY (LIMITED).—This Company was registered on January 22, 1892, with a capital of £75,000, in £5 shares, by Henry F. Kite, 11, Queen Victoria-street, E.C. The objects are to acquire and take over as a going concern the buisness now carried on by the Laing, Wharton and Down Construction Syndicate (Limited), at Reading, in the county of Berkshire, under the style of "The Reading Electric Light Depôt," to carry on the business of an electric supply company in all its branches; and in particular to construct, lay down, establish, fix and carry out all necessary cables, wires, primary, secondary, and other batteries, accumulators, lamps, apparatus and works; to generate, accumulate, distribute, and supply electricity and electrical energy; and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity and electrical energy for the purposes of light, heat, sound, motive-power or otherwise, and to manufacture, buy, sell, hire, use, let and deal in dynamos, lamps, wires, cables, wires, insulating materials; accumulators, primary, secondary, and other batteries, telephones, and other apparatuses. The subscribers are:—

	Shares.
C. J. Wharton, 38, Parliament-street, Westminster, S.W., electrical engineer	1
A. J. Ireland, 13, Minch-avenue, Harlesden, N.W., electrical engineer..	1
H. Lee, 27, Garfield-road, Lavender Hill, S.W.	1
H. W. Jones, 87, Balfour-road, Highbury New Park, N., electrical engineer	1
E. E. Carpenter, Johnson Villa, Gleneagle-road, Streatham	1
J. W. Piper, 37, Vernon-road, Bow, E.	1
S. W. Wise, 14, Silvester-road, East Dulwich, S.E.	1

Registered without Articles of Association.

CAMBERWELL AND ISLINGTON ELECTRIC LIGHT AND POWER SUPPLY (LIMITED).—The first annual return of the above-named Company, made up to January 4, 1892, was filed on January 18, 1892. The Company was registered on June 28, 1890, with a nominal capital of £1,000, divided into 900 ordinary and 100 founders' shares of £1 each. At the time of making up, 7 founders' shares had been taken up, the full amount being considered as paid upon each. The original signatories are the only shareholders, and no agreements for the taking over of any businesses, contracts, plant, &c., have as yet been filed. Registered office: Westminster Chambers, 5, Victoria-street, Westminster, S.W.

DEVONSHIRE ELECTRIC LIGHT AND POWER SUPPLY (LIMITED).—The first annual return of the above-named Company, made up to January 4, 1892, was filed on January 18, 1892. The nominal capital is £1,000, divided into 900 ordinary and 100 founders' shares of £1 each. Seven founders' shares only have been taken up, the full amount being considered as paid upon each. Registered office: Westminster Chambers, 5, Victoria-street, Westminster, London, S.W.

EAST COAST ELECTRIC LIGHT AND POWER SUPPLY (LIMITED).—The first annual return of the above-named Company, made up to January 4, 1892, was filed on January 18 following. The nominal capital is £1,000, divided into 900 ordinary and 100 founders' shares of £1 each. Seven founders' shares only have been taken up, all of which were issued as fully paid. Registered office: Westminster Chambers, 5, Victoria-street, Westminster, S.W.

ELMORE'S PATENT COPPER-DEPOSITING COMPANY (LIMITED).—The annual return of the above-named Company, made up to the 13th January, 1892, was filed on the 21st January following. The Company was registered on the 18th January, 1889, with a capital of '£200,000, in £2 shares, to purchase, take over and work the whole of the British patents of Messrs. F. E. and A. S. Elmore, and numbered 10,720 of 1884; 1,737 of 1885; 4,499 of 1885; 8,707 of 1885; 10,451 of 1885; 11,800 of 1885; 9,214 of 1886. Together with the following Provisional Specifications of British Patents, being numbers 11,778 of 1888; 12,022 of 1888; 12,264 of 1888; and complete specification 16,637 of 1887; and all improvements relating to the treatment and electrical deposition of copper and other metal articles, and to carry on the business of an electric light company in all its branches, including that of electricians, electrical contractors, mechanical and electrical engineers and suppliers of electricity. At the time of making up, 77,295 out of the 100,000 shares had been taken up, and upon all of these the full amount (£2) had been called, resulting in the payment of £107,990. The total amount agreed to be considered as paid on 23,300 shares was £46.600, and £7 10s. has been paid on 15 shares forfeited. Registered office: 64, Cannon-street, London, E.C.

ELMORE'S WIRE MANUFACTURING COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 13, 1892, was filed on January 22nd following. The company was registered on March 15, 1890, with a capital of £300,020, divided into 150,000 ordinary and 10 founders' shares of £2 each, to acquire from Elmore's Patent Copper Depositing Company (Limited) certain patent rights, licences, and privileges, and to carry on the business of an electric light company, including that of electricians, mechanical and electrical engineers, electrical contractors, suppliers of electricity, and manufacturers of and dealers in electrical apparatus and appliances. At the time of making-up, 66,025 ordinary and all the founders' shares had been taken up, upon all of which the full amount had been called, resulting in the payment of £119,318. 15s., and leaving £12,751. 5s. in arrears; £390 has been paid on 1,360 shares forfeited. Registered office: 64, Cannon-street, London, E.C.

FOWLER, LANCASTER AND CO. (LIMITED).—Resolutions passed at an extraordinary general meeting of the shareholders of the above Company, held on November 11, 1891, and confirmed November 30, 1891 (the notice of which was filed on December 29, 1891), as follows:—"(1) That the borrowing powers of the Directors, under Clause 8 of the Articles, be increased by striking out the figures '£3,000' and inserting in their place the figures '£5,000 in addition to debentures.'" "(2) That the time required for giving notices for meetings be reduced by striking out the word 'fourteen' in Clause 73 of the Articles, and inserting in its place the word 'five.'" "(3) That the Directors be authorised to raise £7,000 in addition to their powers in Clause 8 of the Articles, and to issue Six per Cent. Debentures or Bonds, namely, forty at £50 each, and fifty at £100 each, on the terms proposed by the solicitor, and to instruct him to prepare the debentures or bonds and the necessary documents." (Signed) A. Percy Smith, secretary. Clause 8 of the Articles now read:—"The Directors may forthwith, after the incorporation of the Company, from time to time, at their discretion, borrow or raise any sums of money for the purposes of the Company, upon such securities and upon such terms as they may think proper, but so that not more than £5,000 in addition to debentures be owing at any time without the sanction of a general meeting." The above-named Company was registered on January 8, 1890, with a capital of £22,000 in £10 shares. At the time of the last return, which was made up to November 25, 1891, and filed on December 5, 1891, 1,782 shares had been taken up, upon 1,162 of which the full amount had been called and paid, with the exception of £220; 620 shares had been issued as fully paid. Registered office: Albert Works, Graham-street, Birmingham.

PADDINGTON AND BAYSWATER ELECTRIC LIGHT AND POWER SUPPLY (LIMITED).—The first annual return of the above-named Company, made up to January 4, 1892, was filed on January 18th following. The Company was registered on June 30, 1890, with a nominal capital of £1,000, divided into 900 ordinary and 100 founders' shares of £1 each, to supply the parish of Paddington and elsewhere with electric light, electricity, electrical currents, or force, heat, motive-power, or telegraphic, telephonic, or other means of communication. At the time of making-up seven founders' shares had been taken up, all of which were issued and considered as fully paid. The original subscribers are the only shareholders. No agreement for the acquisition of any business, plant, contracts, &c., have, as yet, been filed. Registered office: 13, Victoria-street, Westminster, London, S.W.

PROVINCIAL ELECTRIC LIGHT AND POWER SUPPLY (LIMITED).—The first annual return of the above-named Company, made up to January 4, 1892, was filed on January 18, 1892. The Company was registered on June 28, 1892, with a nominal capital of £1,000 divided into 900 ordinary and 100 founders' shares of £1 each, to carry on, either in the provinces of Great Britain or elsewhere, the trade or business of electric lighting. At the time of making up seven founders' shares had been taken up, all of which, however, were issued and considered as fully paid, the original subscribers being the only shareholders. No agreements for the taking over of any businesses, plant, contracts, &c., have as yet been filed. Registered office: Westminster Chambers, 5, Victoria-street, Westminster, London, S.W.

PUTNEY AND HAMMERSMITH ELECTRIC LIGHT AND POWER SUPPLY (LIMITED).—The first annual return of the above-named Company, made up to January 4, 1892, was filed on January 18th following. The Company was registered on June 28, 1890, with a capital of £1,000, divided into 900 ordinary and 100 founders' shares, as the "Stamford Hill, Tottenham, and Edmonton Electric Light and Power Supply (Limited)," which name, however, was by special resolution passed June 3, 1891, and duly confirmed on June 24, 1891, changed to its present title. At the time of making up, seven founders' shares had been taken up, upon which, however, the full amount had been considered as paid. The original subscribers are the only shareholders. Registered office: Westminster Chambers, 5, Victoria-street, Westminster, S.W.

CITY NOTES, &c.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—Mr. Emile Garcke has resigned the position of Managing Director of this Company, but retains his seat on the Directorate. Messrs. J. S. Raworth and R. P. Sellon have been appointed general managers, and Mr. W. Geipel is now superintending engineer.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended January 24th amounted to £811, as against £743 for the corresponding period of 1891, an increase of £68. The total receipts to date, from January 1, 1892, are £2,827, against £2,627 in the corresponding period of 1891, an increase of £200.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—At a meeting of the Directors held on Wednesday, the audited accounts for the half-year to December 31st were submitted, and it was resolved, after providing for the dividend on the preference shares, to recommend the payment of a dividend on the ordinary at the rate of 8 per cent. per annum, free of income tax.

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EASTERN TELEGRAPH COMPANY (LIMITED).—This Company notify that the coupons on their Five per Cent. Debentures, due February 1st next, will be paid on and after that date at the banking house of Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

EASTERN AND SOUTH-AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company announce the payments by warrants on February 1st next of interest for the half-year ending January 31st on their Four per Cent. Mortgage Debentures. The transfer books of the Company will be closed from January 29th to February 1st, both days inclusive.

HASTINGS AND ST. LEONARD'S-ON-SEA ELECTRIC LIGHT COMPANY (LIMITED).—The annual meeting of this Company was held on Tuesday, when a dividend at the rate of 7½ per cent. was declared for the past year. It was mentioned that, in order to meet the increased demand for the electric light, an extension of the plant was again necessary, and an additional issue of shares would be shortly offered to the shareholders. Mr. Hammond, who is largely interested in the Company, wrote a letter which was read to the meeting, in which he congratulated his fellow shareholders upon the favourable position of the Company. The retiring Directors—Mr. H. M. Baker, jun., and Mr. G. Roddis—were re-elected.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY (LIMITED).—The annual general meeting of this Company was held on Monday, at the Station Hotel, Newcastle, when the report and balance-sheet were adopted, and a dividend at the rate of 4 per cent. per annum was declared for the year ending December 31, 1891.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Jan. 19.		Price Wednesday, Jan. 27.		Rate per Cent. Yielded.	Dividend Due.	Business done during Week ending Jan. 27.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/6	Anglo-American	50½	51½	51	52	5 1 4	Jan., Apr., July, Oct.	51⅛	51
£2,849,510	Stock	25/0	Do. Preferred	89½	90½	89½	90½	5 11 1	" "	90⅜	89¼
£2,849,510	Stock	5/0	Do. Deferred	13¼	13⅜	13	18½	..	" "	13 7/16	13⅜
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99	102	99	102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10½	10⅝	10½	10⅝	7 12 5	Mar., June, Oct., Dec.	10⅝	10⅜
£68,200	£100	5%	Do. 5 per Cent. Bonds	102	105	102	105	4 15 3	January and July ..	103	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 5	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	153	157	153	157	4 9 2	April and October ..	157	155⅞
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	..	..
6,000	10	1 0%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	17	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½	3⅝	3½	3⅝	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	8/6	Direct United States	10⅜	11⅛	11	11½	6 5 0	Jan., Apr., July, Oct.	11 3/16	11 1/16
400,000	10	2/6	Eastern	14⅜	14⅝	14⅜	14⅝	3 16 0	" "	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15⅜	15
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	108	107½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108	111	108	111	4 10 1	February & August	..	..
250,000	10	2/6	Eastern Extension	15	15½	15½	15⅝	4 6 1	Jan., Apr., July, Oct.	15 3/16	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107	110	107	110	3 12 9	February & August	108	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102	105	102	105	4 15 3	January and July ..	103½	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	101	104	101	104	4 16 2	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99	102	99	102	3 18 5	February and August	..	..
180,227	10	2 0	Globe Telegraph and Trust	9⅞	10	9⅞	10⅛	5 6 2	Jan., Apr., July, Oct.	10⅛	10
180,042	10	6%	Do. 6 per Cent. Preference	14⅞	15	14⅞	15⅛	3 12 7	" "	15	14¼
150,000	10	5/0	Great Northern	19	19½	19	19½	4 7 2	Jan., April, and July	19⅝	19
£120,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 0 1	March & September	..	..
9,000	8	4/0	Reuter's	7⅞	8½	7⅞	8	5 3 2	April and October..	7¾	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	116	121	116	121	4 18 4	" "	116	..
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	100	103	101	104	4 6 7	March & September	103	102
80,000	10	2/0	West Coast of America	4	5	4	5	..	January and July ..	4 1/16	4¼
£150,000	100	8%	Do. Debentures 8% 1902	90	103	90	103	7 15 4	June and December	..	..
88,321	10	1/0	West India and Panama	1⅝	1⅞	1⅝	1⅞	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9	9½	9½	9½	6 3 1	May and November	9¾	9⅝
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7½	8½	8	9	6 13 4	" "	..	..
67,007	15	6/0	Western and Brazilian	10	10½	10	10½	7 2 10	" "	10⅜	9⅞
30,864	7½	6/0	Do 5 per Cent. Cumulative Preferred	6½	6⅞	6½	6⅞	5 7 3	" "	..	..
30,864	7½	7/6	Do. 5 per Cent. Deferred	3⅞	4¼	3⅞	4¼	..	" "	4	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104	107	104	107	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	104	107	104	107	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜	½	⅜	½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	7/16	9/16	7/16	9/16	6 8 11	Yearly	½	..
438,984	5	2/6	National	4¼	4⅜	4⅜	4⅝	6 17 2	June and December	4 1/16	4¼
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	12⅞	12½	13	4 12 4	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12	12½	12	12½	4 16 0	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	104	107	105	107	4 4 1	January and July ..	105⅜	105½
58,000	5	1/0	United River Plate	1	2	1	2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	80	90	80	90	5 11 1	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
31,152	£10	..	City of London Electric Lighting (£6 paid)	6¼	6⅜	6	6½	..	—	6½	6¼
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
8,332	£5	..	House to House Electric	4½	5	..	..	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5⅞	6	..	..	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½	6	..	..	..	January and July ..	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2⅝	2⅞	2⅝	2⅞	..	March	..	..
10,000	£5	3½%	Do. (fully paid)	4⅞	5	4⅞	5	..	March	..	..
111,000	5	..	London Electric Supply	1	1½	1⅛	1⅜	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½	10	9	9½	..	..	9⅞	9½
6,318	10	..	Notting Hill Electric Lighting (fully paid)	5½	6½	5½	6½	..	..	6	..
18,680	£5	3/6	St. James' and Pall Mall	8½	9	8½	9	—	..	8 1/16	8 1/16
7,900	£5	7%	Do. 7% Preference	7	7½	7	7½	..	..	7⅜	..
42,853	5	..	Westminster Electric Supply (fully paid)	6½	7	6½	7½	..	..	7 7/16	6 13/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	6%	Brush Electrical Engineering	3⅛	3⅜	3⅛	3⅜	..	..	3 1/16	3⅜
69,996	2	6%	Do. 6 per Cent. Preference	2⅛	2⅜	2⅛	2⅜	5 1 1	..	2 1/16	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5⅛	6	5⅛	6	5 16 8	January and July ..	5⅜	1/8
17,130	5	17½	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	6	6¼	6	6⅛	..	—	6⅛	6
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅜	3⅝	3⅜	3⅝	..	—	3⅝	3½
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20½	21½	21½	22	4 10 11	February & August	22½	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	3½	4½	3½	4½	..	..	3⅞	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛	⅜	⅛	⅜	..	..	..	..
78,949	5	1/7½	Swan United (£3. 10s. paid)	3⅞	4¼	3½	4	9 13 0	May and November	4	5⅜
86,250	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July.....	43½	42⅞
150,000	100	5%	Do. 5 per Cent. Bonds, red 1894	100	103	100	103	4 17 1	January and July .	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	1⅜	1⅝	1⅜	1⅝	5 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	3½	3¾	3½	3¾	10 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
50,000	£10	—	City and South London Railway	2½	3½	2½	3½	..	..	3⅛	..

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THE ELECTRICIAN:

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NOTES.

To say that a large audience was enchanted by the long-expected lecture of Mr. Nikola Tesla on Wednesday night is no exaggeration; for as soon as he grasped his long glass tubes they glowed with softened splendour, as, magician-like, he waved them over his head, and little bulbs of glass with phosphorescing powder gleamed with a weird, if not ghastly, radiance when merely hung on his finger tip. Vainly did the unscientific members of the audience whisper to their neighbours, "How is it done?" And in his enthusiasm the lecturer, who seemed to love his wonderful lamps and globes, forgot to give an explanation. The more initiated flinched at the ominous crackle of the high-pressure discharges, and looked with some apprehension at a wooden box in which a magnetic interrupter was enclosed, and from which flames rose when the current was turned on. But the flames were shut down with an ordinary wooden lid, and the spluttering terminals shot out angry discharges at an iron clamp which the lecturer presented to it when he wished to convey a few hundred thousand volts through his body to a vacuum tube.

The apparatus used by Mr. Nikola Tesla is of the simplest description, but the arrangement of the subsidiary parts is complicated, and the adjustments are numerous and difficult to make. The high-frequency dynamo, which was placed in the dynamo-room of the Royal Institution, is most remarkable for its unsophisticated and plain design. It consists of a stationary armature, about 30 inches diameter, with 380 inwardly projecting coils, like those of a Parker alternator. A thin iron disc, like a fine-pitch gear wheel, is provided with 380 tiny magnets connected-up in series, runs with very small clearance, and generates a current with some 13,000 periods per second. This dynamo and several of the more characteristic experiments were described and illustrated in *The Electrician*, Vol. XXVII., p. 332. But no illustrations can convey an idea of the beautiful effects to those who have not seen them; and no report of the lecture can give to those who were not present, such an insight into Mr. Nikola Tesla's attractive personality as it was the privilege of his audience to enjoy.

The audience which gathers at the meetings of the Institution of Electrical Engineers is, probably, the most youthful of any scientific society; but several of the well-known men who often attend and take part in the proceedings are not members of the Institution. The Institution of Civil Engineers not only offers admirable accommodation, but provides a few members who contribute very usefully to the discussions. Some of these have been startled to find that their prerogative as members of the older Institution was of no avail for gaining admission to Mr. Nikola Tesla's lecture, and had to beg for tickets from members of the Institution of Electrical Engineers. That these tickets could be used for admitting strangers to the theatre of the Royal Institution came as a surprise when announcement was made to this effect after Prof. Ayrton's address; but this hope was rudely shattered by a circular, dated February 1st, which withdrew this privilege. As a last resource, several country members were appealed to by telegraph, and were good enough to send their post cards to their more fortunate London friends. By a fortunate combination of circumstances the theatre was just full, and no one was turned away. We understand that the Institution of Civil Engineers can accommodate only 400, and that the audience on Wednesday numbered about 800.

Some rather severe criticisms were made by *The Spectator* a few months ago on the habit, into which some scientific men are apt to fall, of "taking the public into their confidence, making known to it discoveries that are as yet only half known to themselves, and building upon the basis of those discoveries a bewildering fabric of conjectural possibilities." Criticism of such "fairy tales" is, no doubt, sometimes justifiable, but we see little reason for being severe. *The Spectator* remarked, in the article from which we recently gave extracts in our "Notes" columns, that its ignorant mind thus became confused with wild conjectures. If the science, so far as it goes, is correct, and the conjectures which go beyond, are fairly logical, such dissertations have a Jules Verne-like romance, and harmlessly amuse the public with ideas of these "half-baked notions" with which some thinkers are busying themselves.

To this kind of literature Prof. Crookes makes a large contribution in this month's *Fortnightly Review*. Ether vibrations, especially those of greater wave length than light, are discussed. The details are perhaps accurate enough for general readers, but the initiated will discover one or two slips. Beings are imagined who have eyes which are "sensitive to the vibrations concerned in electric and magnetic phenomena." "Glass and crystal would be among the most

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opaque of bodies. Metals would be more or less transparent, and a telegraph wire through the air would look like a long narrow hole drilled through an impervious solid body. A dynamo in active work would resemble a conflagration; whilst a permanent magnet would realise the dream of mediæval mystics, and become an everlasting lamp with no expenditure of energy or consumption of fuel." There seems to be some confusion here. Surely HERTZ transmitted his vibrations through air, and screened them by metal sheets. The idea of comparing a conductor to a hole in a solid substance is connected with a rather barbarous but none the less abstruse theory of fluid currents. The longest wave length to which these imaginary eyes are sensitive is not given; but, as far as we are aware, no remarkable ether vibrations emanate from any dynamos but alternators; and the wave length of these is measured in thousands of miles. The most unwarrantable speculation is the one about the blazing magnet. The permanent magnet throws out no oscillations of any kind that have ever been published; and if Prof. CROOKES has any private information about them, we should like to learn what it is. Prof. FITZGERALD, at the last meeting of the Physical Society, aptly compared the continuous production of ether vibrations to the blowing of a whistle, and the snap of a Leyden jar to the drawing of a cork; but what such analogue is to be found for the passive condition of a permanent magnet? Electric whirls round magnetic lines of force are indeed alluded to in Prof. OLIVER LODGE'S "Modern Views;" but even if these be considered as causes in the Ampèrian sense, and not effects, we still have no Hertzian vibrations.

AFTER quoting largely from "Modern Views" Prof. CROOKES says: "Could we construct Leyden jars of molecular dimensions, Prof. LODGE considers the rays might fall within the narrow limits of visibility." This statement tends to confirm a rather erroneous interpretation which has been placed upon the original words. Prof. LODGE calculated that to produce waves 25 millionths of an inch long "the necessary circuit must have a self-induction in electro-magnetic units, and a capacity in electrostatic units such that their geometric mean is 10^{-5} centimetre. This gives us at once something near atomic dimensions for the circuit, and suggests immediately that those short ethereal waves which are able to affect the retina, and which we are accustomed to call 'light,' may be really excited by electrical oscillations or surgings in circuits of atomic dimensions." But the diameter of a molecule, or as it has been more cautiously expressed, the mean distance between the centres of contiguous molecules, is probably less than 2×10^{-7}, and greater than 10×10^{-9}. Molecules, according to the present state of knowledge, are much too small to make good Leyden jars for the cheap generation of light; and, as is clearly stated on p. 267 of "Modern Views," it can be calculated that the oscillation of an atomic charge would give rise to only ultra-violet rays.

THE two most recent and by no means least interesting additions to this subject are the suggestion that the merely mechanical vibrations of a molecule are more comparable with light undulations, and that examples of bodies which are actually of the dimensions suitable for electric oscillations are to be found in the rods and cones of the retina.

Aachen.—The erection of the central station at Aachen has been entrusted to Messrs. Schuckert and Co., of Nurnberg.

Personal.—Mr. T. Parker, of the Electric Construction Corporation, has been elected a Fellow of the Royal Society of Scotland.

The Bakerian Lecture.—The delivery of this lecture has been fixed for March 17th, and Prof. James Thomson has been invited to deliver it.

Royal Institution.—Lord Rayleigh will on Saturday (February 13th) begin a course of three lectures on "Matter: at Rest and in Motion."

Telephone in Italy.—A line of telephone, thirty miles long, the first that unites two Italian cities, has been opened between Milan and Pavia.

Electric Lamps for Omnibus Inspectors.—The London General Omnibus Company has supplied all their ticket inspectors with small electric lamps.

Burnley.—The electric lighting canvass having been satisfactory, it has been decided to engage an electrical engineer, with a view to advising the Corporation as to the best system to be used.

Dresden.—The first electric tramway in Dresden will be laid down during the summer. It will extend from the Schlossplatz to Loschwitz, and is to be worked by Messrs. Siemens and Halske.

Toronto.—The chief electrician of the Toronto Electric Light Company, while passing in the vicinity of a large dynamo on Sunday night, accidentally completed the circuit, and was severely injured.

Johannesburg.—The Johannesburg Lighting Company have installed some arc lights in the principal streets of Johannesburg, and as soon as the additional capital required can be raised will commence private lighting.

Heilbronn.—Since the 6th of January tests have been made on the line for the high-pressure transmission of power between Lauffen and Heilbronn, and it is expected that the ordinary working will now shortly be started.

Bristol.—At a recent meeting of the Town Council, it was decided, upon the report of the Electrical Committee, to pile the whole of the site of the new central station, instead of the walls and chimney stack only, at a cost of £9,659.

Royal Society.—At the Council Meeting of the Royal Society on January 21st, no fewer than ten deaths were announced, seven Fellows and three Foreign Members. The average number of deaths for the entire year is fifteen.

The Yokohama Central Station.—Amongst the buildings which suffered from the earthquake shocks which occurred in Japan on October 28th was the station of the Electric Lighting Company. The station was practically destroyed.

Dublin.—The Town Clerk of Dublin has been directed to convey to the Electrical Engineering Company the desire of the Corporation that all their material, as far as possible, used in the city electric light works should be procured in Ireland.

The Waterloo and City Railway.—At a special general meeting of the London and South-Western Railway Company, held yesterday, it was resolved to approve of the Bill to be laid before Parliament authorising the construction of this railway.

Electric Traction in Belgium.—The Belgian Minister of Railways has caused a report to be drawn up on the results obtained on the electric lines at Vevey-Montreux, Moedling-Hinterbrühl, Blackpool, and other places, with the object of seeing what advantages could be obtained by the adoption of electric traction on railways.

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Portsmouth.—The Town Council has revoked its previous decision to light the town with electricity on the low-pressure system, and has adopted a new high-pressure scheme, estimated to cost £38,000. An amendment for deferring the scheme until the question of using tidal power for machinery was considered was lost by the Mayor's casting vote.

Physical Society's Report.—On p. 329 of our last issue, second column, line 5 from bottom, *for* $Q = Q_0 \epsilon^{-r/L\,t} \cos 2\pi t/T$ *read* $Q = Q_0 \epsilon^{-\frac{r\,t}{L}} \cos \frac{2\pi t}{T}$. Line 4 from bottom *for* $\epsilon^{-r/L\,t}$, *read* $\epsilon^{-\frac{r\,t}{L}}$.

Oldenburg.—The lighting of the ministerial buildings at Oldenburg will soon be at work. The job has been in the hands of Messrs. Schuckert and Co., who have put down two 100 H.P. turbines to be driven by the river Hunte. Sufficient power will be available to light the palace, the castle, and the theatre, but at present the ministerial offices and the bank only are to be lighted by electricity.

Standards of Light Committee.—The following is a list of the names of the Committee appointed by the Board of Trade to inquire into and report upon the subject of the standards to be used for testing the illuminating power of coal gas:—Mr. W. J. Dibden, Prof. E. Frankland, F.R.S, Mr. H. E. Jones, Mr. George Livesey, Prof. Wm. Odling, F.R.S., Mr. George Rose-Innes, Mr. W. J. Russell, F.R.S., Mr. G. C. Trewby, and the Gas Referees; Prof. Vivian B. Lewes being secretary.

An Electric Mail Car.—On the St. Louis and Suburban Electric Railway there is now in successful operation a United States mail car, which makes regular trips over the entire line, distributing and collecting the mail at the different railway stations. This car is of the same length as an ordinary steam railway mail car, and is equipped with double trucks with 36-inch wheels, a Thomson-Houston motor of 15-horse power capacity being connected to each truck. A very high speed is attained, and the delivery and collection of mails is made without stopping the car.

Copper.—Although the stock of copper in England and France and afloat was smaller at the end of January than it had been at the same date for three years previously, the price is considerably lower. According to Messrs. H. R. Merton and Co.'s statistics, the stock on January 31, 1892, was 57,462 tons, as against 61,396 tons in 1891, 95,714 tons in 1890, and 109,528 tons in 1889. Yet the price this year was £44. 12s. 6d. per ton, as compared with £52. 12s. 6d. per ton, £48. 17s. 6d. per ton, and £77. 10s. per ton on the same day in the three preceding years.

Obituary.—The death is announced of Mr. Thomas Wood Eason, Superintendent of the Dublin Telegraph Department. Thirty-five years ago he entered the service of the old Magnetic Telegraph Company in his native city of Cork; and at the time of the transfer of the telegraphs to the State in 1870 he was appointed Superintendent of the Belfast Telegraph Department, a position which he filled with marked ability. Subsequently, in 1882, on the chief post of the Dublin telegraph branch becoming vacant, Mr. Eason was appointed thereto, and he continued to hold it until his death.

The Magnetic Properties of Liquid Ozone.—At the meeting of the Royal Society on December 17, 1891, the following letter was read from Prof. Dewar:—

Royal Institution, December 17, 1891.

Dear Sir William Thomson: I had intended coming to the Society, in order to make a further communication with regard to the magnetic and other properties of liquid oxygen; but I am confined to the laboratory, owing to difficulties with regard to the progress of such investigation. In the meantime it may interest the Fellows to know that I have examined the properties of liquid *ozone* in the magnetic field, and find it also highly attracted. I hope to make a detailed communication very soon to the Society. JAMES DEWAR.

Frictional Electricity.—From a series of experiments made a short time ago, Prof. Wesendonck, of Berlin, inferred that dustless air, in friction with metals, does not generate electricity. But carbonic acid, under like conditions, readily gave a charge, and this was thought to be due to cloud-formation in the gas streaming out of the vessel which had held it in liquid form, the small water-particles charging the metal by friction. Further experiment has seemed to confirm this view. Prof. Wesendonck concludes that gaseous carbonic acid is not capable of generating electricity by mechanical friction on metal.

Mining Operations by Electricity.—Considerable interest, says the *Newcastle Journal*, is being evinced in mining circles generally as to the result of an important electric mining installation at one of the Earl of Durham's collieries, which, when finished, will be the largest and most complete electric mining plant as yet erected in this country. The operations to be effected consist of electric haulage, winding, pumping, lighting, signalling, telephoning, &c. The contract is being carried out by Messrs. D. Selby, Bigge, and Co., of Newcastle-on-Tyne, the machinery being built for them by Messrs. W. T. Goolden and Co.

Association Suisse des Electriciens.—We are in receipt of the "Annuaire" of this Association for 1892. In addition to the information usually given in publications of this kind, viz., a list of members of the Association, and its rules and regulations, there is a list of the leading Swiss electrical firms, together with telegraphic, telephonic, and electric lighting statistics; and a number of Federal laws bearing on electrical matters and on patents. The volume concludes with the report of a Committee of the Association with reference to the nationalisation of the waterfalls of Switzerland—a burning question in that fortunate country.

A New Launch Charging Station.—A new electric launch charging station is now being built at Eel-pie Island, Twickenham, for Mr. W. S. Sargeant, who will shortly transfer from Strand-on-the-Green, Chiswick, the business he there carries on as steam and electric launch builder, to Eel-pie Island. Here it will be conducted under the style of the Thames Electric and Steam Launch Company, and for this purpose large works are now being erected on the island. Several orders for new electric launches have been booked, one being for a boat 75ft. long, 13ft. beam, and draught aft 3ft. 6in. This will be larger than the "Viscountess Bury," which at present is the largest electric launch in the world.

Telegraphing by Electrostatic Induction.—A patent has just been granted to Mr. Edison for a system of transmitting signals electrically without the interposition of connecting wires. Several claims are made, but the principal one is the following:—"I claim as my discovery means for signalling between stations separated from each other, consisting of an elevated condensing surface or body at each station, a transmitter operatively connected to one of said condensing surfaces for varying its electrical tension in conformity to the signal to be transmitted, and thereby correspondingly varying the tension of the other condensing surface, and a signal receiver operatively connected to said other condensing surface, substantially as described."

A Four Years' Electrical Engineering Course.—An undergraduate course of four years in electrical engineering has been established in the School of Mines, Columbia College, in addition to the present two-year post-graduate course which has been in successful operation for several years. There will thus be two complete courses in electrical engineering in New York. The latter course is for graduates of scientific schools and colleges, and is entirely devoted to electrical engineering proper, the students having already passed the necessary preparatory studies in mathematics, physics, chemistry, mechanics, drawing, &c. This course is found to give the most excellent results by reason of the maturer years and better training of post-graduate students.

The Development of Electric Tanning.—According to *La Lumière Electrique* several French tanners have adopted the electric tanning process, but have not made the fact public "for fear of displeasing a clientèle always distrustful of new methods." The Société Brion et Dupré is known to employ six drums, capable of an annual output of 600 tons of tanned hide. In Portugal there are two electric tanneries at work, at Porte and Braga, having an annual output of 700 tons of tanned hide; and in Madagascar an electric plant is being set

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up. In Brazil, at Boa Vista, some eight miles from Rio de Janeiro, there is an electric tannery covering about 13 acres, and possessing no less than 100 drums. The annual output of the Boa Vista plant will ultimately be about 70,000 tons.

Electric Light Signalling Experiments.—Experiments are being carried out on board the "Defiance" at Devonport with arrangements for night signalling by means of electric lights placed at the masthead. The experiment has frequently been tried, but hitherto with only partial success, owing to the difficulty of rendering the flashes distinct from each other, the lamps continuing to exhibit a faint glow for some time after the electric current has been shut off. Owing to this disadvantage signalling by electric lamps can at present only be carried out at the rate of less than 50 signals per minute, which is not found to be sufficiently rapid. In the experiments in question incandescent lamps are used, and the connection is made and cut off from the deck with a series of shutters actuated by electro-magnets.

Gas Concessions and Electric Lighting in France.—The French electrical papers chronicle two decisions of considerable importance to electric lighting enterprise in France which have just been rendered by the Conseil d'État. These decisions are based upon the terms of the concessions granted by the municipalities of Montluçon and Saint Etienne to the local gas companies, concessions of much the same monopolistic character as that granted by the municipality of Sedan, the contravention of which recently landed that body in a lawsuit, and the payment of 14,000fr. damages. (*The Electrician*, November 13, 1891, p. 23 and p. 26.) The Conseil d'État held that the concessions granted to the gas companies of Montluçon and Saint-Etienne gave them the monopoly of the street lighting and the exclusive right of making use of the roads for the distribution of illuminants, whether gas or electricity. The Conseil d'État consequently cancelled the electric lighting concessions.

The Repulsion and Rotation produced by Alternating Electric Currents.—In a Paper on this subject, communicated to the Royal Society in December last, Mr. G. T. Walker, of Trinity College, Cambridge, gives some expressions for calculating the intensities of the force and couple respectively experienced by a ring of metal placed over and by a ring of metal pivoted over an alternating electro-magnet. He also investigates the well-known experiment of Professor Elihu Thomson, in which a sheet of copper is placed so as to half cover an alternating magnetic pole, and a hollow copper sphere is laid upon the plate; the electro-magnetic action producing a couple sufficiently powerful to overcome friction and to spin the sphere round. According to Mr. Walker, the sphere spins round in virtue of the fact that the currents induced in the copper plate "do not coincide in phase with those of the magnet, and not (as has been stated) because it acts as a screen, and renders the field unsymmetrical. Were the plate a perfect conductor, it would be a perfect screen, but there would be no couple."

Dynamo Speed Regulation.—Owing to the variations of load and water pressure, most turbines, says Herr Adolf Zoeppritz in the *Elektrotechnische Zeitschrift* for January 1st, are liable to considerable variations of speed; and at some textile works at Heidenheim the following device has been adopted to maintain an approximately constant speed and quick automatic regulation of a turbo-dynamo. Between turbine and dynamo there is a coned countershaft, and the belt from the turbine is shifted along the cone by the action of a centrifugal governor attached to the turbine. Theoretically, there is no limit to this method, but practically the greater the difference between two successive speeds of the turbine the further the belt has to be moved, and the longer is the time which elapses before equilibrium is restored. Now, the speed of a lightly-loaded turbine varies less for a given change of load than that of one fully loaded; and hence at Heidenheim an 18H.P. turbine is used to run a 4H.P. dynamo. So that the device is only applicable where water power is superabundant.

Law of the Magnetic Circuit.—It is curious, remarks *Industries*, that nearly all electrical engineers think that magnetism follows Ohm's, or an analogous law. It really does not follow any such law. Ohm found by experiment that $E/C = R$. That is a definite law, R depending on the ratio of E and C, and not on their absolute value. The analogous magnetic "law" merely amounts to a definition. It is not a statement that the resistance is equal to the ratio of the "magneto-motive force" to the flux, as that is not the case. The resistance depends on the values as well as on the ratio of these quantities, so that we have only a definition left, with no underlying law whatever. Some say, "When there is a magneto-motive force and a flux we will call their ratio the magnetic resistance." The ratio of any two quantities may be given a name, but that does not provide any analogy to Ohm's law. Of course, it must not be forgotten that current and induction are both solenoidal, but solenoidal distribution is met with in so very many branches of physics that it affords no special analogy between current and induction in particular.

Cable and Land Line Interruptions and Repairs:

	Date of interruption.		Date of repair.
	1891.		1891.
St. Thomas-St. Kitts Cable	Oct. 13	... .	*
Brest-St. Pierre Cable (Anglo-American)	Nov. 19	.. ..	*
			1892.
Rio Grande-Montevideo Cable ...	Dec. 4	.....	Jan. 6
Hongkong-Cape Bolinao Cable ...	„ 4	.....	Jan. 11
			1891.
Aden-Zanzibar Cable	„ 5	.....	Dec. 23
Jamaica-Porto-Rico Cables	„ 21	.....	„ 21
Argentine Land Lines	„ 23	.....	„ 24
	1892.		1892.
„ „	Jan. 6	.....	Jan. 8
	1891.		
Moulmein-Bangkok Line.....	Dec. 27	.....	„ 5
	1892.		
St. Croix-Trinidad Cable	Jan. 4	.. ..	Jan. 10
Trinidad-Grenada Cable	„ 4	.....	„ 23
Perim-Assab Cable	„ 5	.....	*
Para-Maranham Cable	„ 18	.....	*
San Thomé-St. Paul de Loanda...	„ 22	.....	*

* Not yet repaired.

Arc-Light Carbons.—*L'Electricité* recently discussed in a brief article the ever-fascinating subject (for inventors) of improving the light-giving properties of arc-light carbons by the introduction of rare earths and of reducing the consumption of carbon to a minimum by striking the arc within a closed vessel containing some gas or other. The first commercially successful artificial carbons in France were those of Jacquelain, an assistant of Dumas, the chemist. Jacquelain carbons consisted of pure compressed carbon, obtained by decomposing some hydro-carbon oil. Then came the Carré carbons. Carré used crushed coke, from which all impurities were then eliminated by chemical washings. To obtain dense wood charcoal carbons Sidot and Gauduin heated the charcoal in a stream of bisulphide of carbon, chloride of carbon, or some hydro-carbon. These substances were split up by the heat, and gave up their carbon, which was left in the pores of the wood; the result being heavy carbons giving a sonorous metallic ring. Among the many attempts to produce a satisfactory arc light within a closed vessel were those of the engineers of the Paris Gas Company, the gas employed being ordinary illuminating coal gas. It was said at the time that the net result of these investigations went merely to show that coal-gas was consumed instead of carbon, so that no particular advantage was gained.

The Heat Radiation of Rarefied Gases under the Electric Discharge.—Herr Angström, says *Nature*, has been lately engaged in examining with a bolometer the heat radiation of various rarefied gases under the electric discharge. He confined himself to the stronger positive light, using cylindrical glass tubes, with lateral electrodes, and rock-salt plates at the ends. An accumulator of 800 Planté elements was the source of electricity. Briefly stated, the results are these:—With a given pressure the radiation is proportional to the intensity of the current. With constant current, the radiation does not vary while the pressure varies between 0·1 and 1·5mm., but at higher pressures it increases somewhat. With the same gas and pressure, the composition of the radiation is constant, and does not depend on the intensity of the current. With varying density of gas, the ratio of the intensity of radiation of

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shorter wave lengths to that of the whole decreases with increase of pressure. (This ratio varied, *e.g*, from 46 to 15 per cent. in carbonic oxide between the above pressure limits.) Thus this ratio, at low pressures, reaches much higher values than in our ordinary light sources. The intensity of total radiation varies considerably in different gases, and stands in no simple relation to the molecular weight, nor to difference of potential in the gas; nor does it seem to depend on absorption of gas at ordinary pressure and temperature.

The Tramways of the United Kingdom.—The tramway system of this country, says the *Economist*, has latterly expanded very slowly. In 1889-90 the trifling addition to the mileage was more than counterbalanced by the disuse of lines which took place; and the Parliamentary report which has just been issued for the year ended June 30, 1891, shows that during the year the net addition to the mileage in England was only 15 miles; in Scotland and Ireland there was no growth whatever; whilst there was no increase in the number of tramway undertakings throughout the kingdom. In 1880, 368 miles of tramways were in operation in the United Kingdom; in 1890 the mileage was 948. In 1891 the total mileage was 963, the total capital authorised being £17,909,809, and the total capital expended £14,162,650, making the average cost per mile £14,707. The number of passengers carried during the year ended June 30, 1891, was 565,621,500, against 526,369,000 for the corresponding period, an increase of 7 per cent. The total number of cars is now 4,067, and of horses 29,002. The gross receipts increased during 1890-91 by over 6 per cent. to £3,429,686; this augmentation was, however, more than counterbalanced by the increase in working expenses, which rose from £2,402,800 to £2,630,929, an increase of 9 per cent., which reduced the net earnings to £798,757, making the percentage ratio $\frac{\text{net receipts}}{\text{capital expended}} = 5{\cdot}48$. It is interesting to note that the total "street railway" mileage of Canada and the United States is 11,029, of which electricity is responsible for 3,009 miles, the total number of cars being 36,517.

An Interesting Electrolytic Phenomenon.—In a communication recently made to the Académie Royale de Belgique, Prof. Lagrange and M. Paul Hoho describe some experiments made by them on a luminous and calorific phenomenon which takes place under certain conditions when a current is passed through an electrolyte. The phenomenon was first observed in 1844 by Foucault and Fizeau, and has subsequently also been investigated by Righi, Colley, Planté, and others. Prof. Lagrange and M. Hoho employed in one experiment a 10 per cent. solution of H_2SO_4, the positive electrode being of copper with 180 square cms. in the liquid, the negative electrolyte being a copper wire ¼mm. in diameter plunged into the electrode to a depth of ½mm. Current was obtained from a battery of accumulators. At first only the ordinary phenomena of electrolysis are observed; then, as the volts are increased, bubbling and boiling occur at the negative electrode, next intermittent arcs take place between wire and liquid, finally a luminous cylinder is formed having the copper wire for axis, the current then becomes steady, and the resistance very high. On plunging the wire further into the liquid, this series of phenomena can be reproduced. Much the same effects were produced with platinum, zinc, tin, iron, steel, and carbon electrodes of different diameters, with sulphuric acid solutions of different strengths, and with a chloride of sodium solution. The production of the luminosity is accompanied by an abnormal resistance which is localised round the negative electrode; with electrodes 29 cms. apart, practically all the fall of potential takes place within 5mm. of the negative electrode. The shape of the negative electrodes appears to have but little influence. Luminous effects can be made to occur also at the positive, but with some difficulty. It is, however, impossible to produce luminosity at both poles at the same time.

The Conductivity of Cast Steel.—In a recent article in *La Métallurgie*, M. Campredon gives some interesting particulars with regard to the conductivity of cast steel. He takes as his standard of comparison the electrical resistance of a wire 1mm. in diameter and 1 kilometre in length. Under these conditions copper comes out at 21 ohms, iron at 125 ohms. In the French telegraph contracts, it is stated that wires must be of charcoal iron, but soft steel wire can be substituted. The conductivity of soft steels is in direct relation to its chemical composition and its homogeneity. Tests of conductivity have been made with a certain number of coils whose chemical composition has also been determined. The chemical and electrical results are shown in the following table:—

No. of piece.	Carbon.	Silicium.	Sulphur.	Phosphorus.	Manganese.	Total Impurities.	Resistnce in ohms.
1	·090	·020	·050	·030	·210	·400	127
2	·100	·020	·050	·040	·240	·450	133
3	·100	·020	·060	·040	·260	·480	137
4	·100	·020	·050	·050	·310	·530	140
5	·120	·030	·070	·050	·330	·600	143
6	·110	·030	·060	·060	·350	·610	144
7	·120	·020	·070	·060	·380	·650	149
8	·120	·020	·070	·070	·400	·680	150
9	·110	·030	·060	·060	·490	·750	156
10	·140	·030	·060	·080	·540	·800	173

From this table it will be noticed that soft cast steel conducts much better in proportion to its degree of softness and purity, and that manganese is the element whose presence has the greatest influence. It is not sufficient that steel should be extra soft—it must also be perfectly homogeneous to be a good conductor. Cast steel which is pure, and only slightly manganesiferous, and contains less than 0·700 per cent. of foreign matters, runs off very hot, and consequently sufficiently homogeneous, has a resistance of less than 105 ohms when tested under conditions fixed in the contracts by the Minister of Telegraphs. Such a metal presents, moreover, those physical and mechanical properties which would permit of its being accepted with the same confidence as the earlier charcoal iron.

The South African and International Exhibition.—It is proposed to hold this Exhibition next September, at Kimberley, which is easily accessible by rail. The Cape Government Railway Department is cordially co-operating with the Exhibition, and will reduce the passenger fares and give special facilities to visitors by running special trains at greatly reduced prices. Electricity will play an important part, and will be used in lighting the buildings and grounds. Exhibits from abroad will be brought from any of the ports of the Colony in bond, carriage free, and will not be subject to duty unless they are sold. Diplomas and medals will be awarded to successful exhibitors in every department. The guarantee fund exceeds £17,000, and is expected to reach £20,000. It is proposed that the Exhibition shall remain open for three months. Charge will be made for space for all works sent for exhibition otherwise than by special arrangement. All the larger exhibits, or such as require special fittiugs, must be delivered not later than 15th August. Smaller exhibits can be delivered after that date, but not later than August 25, 1892. All exhibits must be arranged and ready for exhibition before September 1st. Awards will be given for the best electric generator and motor, having the highest commercial efficiency, strength, and simplicity of design, ease in operation, highest insulation, and capability of working in damp places without injury; for the best arc lamp; for the best arc dynamo; for the best incandescent dynamo; for the best electrical fittings. Intending exhibitors are informed that the British and Colonial Steam Navigation Company (Bucknall Bros.) are prepared to convey exhibits outwards at current rates, and bring back unsold exhibits (if any) free of charge, refunding outward charges. The Castle Mail Packets Company, the Union Steamship Company, the South African Steamship Company, the International Steamship Company, and the Clan Line offer special advantages. The London Executive Committee comprises—Sir Charles Mills, Sir Philip Cunliffe-Owen, Sir George Hayter Chubb, Sir Donald Currie, Mr. W. M. Farmer (Union Steamship Company), Mr. H. A. Hedley, Mr. E. P. Mathers, Mr. George J. S. Mosenthal, Mr. John Paddon, Mr. C. I. Posno (Chairman of London and South African Exploration Company), Captain Wisely (Castle Mail Packets Company). The honorary solicitors in London are Messrs. Bircham and Co., of 50, Old Broad-street; and the London manager is Mr. Lewis Atkinson, 3 and 4, Fenchurch-street.

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WILLIAM EDWARD AYRTON, F.R.S.

Prof. W. E. Ayrton, born in 1847, is the son of the late Mr. E. N. Ayrton, a barrister, whose extremely reserved and somewhat repellant manner prevented "his taking the position as a public man for which his remarkable talents so well qualified him." For, as further stated in a long memoir from the pen of a leader at the equity bar, which appeared in the public press at the time of Mr. E. N. Ayrton's death, "He was in every way a remarkable man. . . . . Few men knew more than he did, or more thoroughly what he knew. He was an accomplished linguist and a critical scholar, while he was none the less a master in many departments of science, and was surpassed by few as a lawyer." . . .

Prof. Ayrton's earliest recollection is that of hearing seven different languages spoken at home, one particular language only being always used on each particular day of the week. But the only result of these unusual efforts that were made to give the child a mastery over languages was to develop a fondness for mathematics and science; so that while later on the lad felt a moral obligation to win classical prizes at school, he grew to detest the study of language, and loved to absorb himself in the solution of geometrical problems, and in the carrying out of optical and mechanical effects for a mimic theatre.

Having spent five years at University College School, he studied from 1864 to 1867 at the College under the late Prof. De Morgan, Dr. Hirst, and Prof. Foster, becoming, in the third year of his college course, assistant to the two latter. After gaining the Andrews Prize and the Andrews Scholarship for pure and applied mathematics, in addition to many minor prizes, his attention was turned to India from some ten students at the College coming to him to be prepared for the second examination for the Indian Government Telegraph Service. And after passing, with honours, the first B.A. examination at the London University, he entered the Indian Telegraph Service in 1867.

Coming out far above all the other candidates at the entrance examination, he was sent by the Secretary of State for India to study with Sir William Thomson in Glasgow, and on the result of the second examination in 1868 he was awarded a scholarship, with leave to stay in Europe on full pay to continue his electrical studies.

Proceeding ultimately to India he was appointed assistant to the late Mr. Schwendler, the electrical superintendent of the Indian Government Telegraph Department, and was engaged in introducing throughout the whole of British India a complete system of immediately determining the position of a fault by testing from the end of a telegraph line. In spite of the vast lengths of many of the Indian telegraph lines, on which there are no intermediate telegraph offices to be called in in case of a breakdown, the method of determining the position of faults by electrical testing from the end of the line was quite unused. Hence its introduction led to a great reduction in the average time of transit of a message, a result of great pecuniary importance. For the Indian Government decided that all messages sent between places east and west of India along the Eastern Company's cables, which had then just been laid, must be sent by land between Bombay and Madras, and that the submarine cable that the Eastern Company had arranged to lay round India from Bombay to Madras was unnecessary, and must not be laid. And as the Company based their appeal to the House of Commons against this decision on the bad working of the Indian land lines, it was of vital importance to the Government that they should be rapidly improved.

After having been made acting electrical superintendent, and appointed to take charge of the telegraph offices at Bombay and Calcutta, to enable him to aid in effecting these improvements, Mr. Ayrton returned in 1872 on leave to England, and was employed by the India Office on special duty in connection with the testing of insulators; for he had shown that the great leakage on some of the long Indian lines was due to the fact that a small percentage of the insulators were electrically porous in damp weather, although apparently quite free from flaws, even when examined with a microscope. He was also employed by Sir William Thomson and the late Prof. Fleeming Jenkin in the electrical testing of the Atlantic cable, then being constructed for the Great Western Telegraph Company at Millwall, and subsequently he was placed in charge of the cable-testing department at Mitcham on their behalf.

On the establishment of the Japanese Imperial College of Engineering in 1873, the largest English-speaking technical university of that day, he was offered the Professorships of Physics and Telegraphy, which he held until 1878, carrying out a number of experimental investigations with Prof. Perry, who had charge of the department of Mechanics. The physical laboratories at this college, constructed from Prof. Ayrton's designs, were fully described and illustrated in the *Builder* in 1880, being at that period among the finest in the world.

On Prof. Ayrton's return to England he was for some time adviser to the firm of Messrs. Latimer Clark, Muirhead and Company, whom he left to take in hand the work of the City and Guilds of London Institute, the rapid growth of which is sketched in his inaugural address recently delivered to the Institution of Electrical Engineers (see this and the last number of *The Electrician*).

Having assisted in developing the Finsbury Technical College out of a scheme for a mere trades school, he was in 1884 appointed Professor of Applied Physics at the City and Guilds of London Central Institution. In 1881 he was elected a Fellow of the Royal Society, and in 1889, a Member of Council; while the Royal Society is represented by him on the Council of Almoners of Christ's Hospital, and on the Board of Governors of the Imperial Institute. He has been a Secretary of the Mathematical and Physical Section, and is now a Member of the Council, of the British Association; has served as juror on various Exhibitions; was a Member of the Commission to the Frankfort Exhibition of last year; and is a Member of the Committee of Experts at the Crystal Palace Exhibition. Lastly, the Physical Society and the Institution of Electrical Engineers have now, for the first time, the same President—Professor Ayrton.

Dr. Wormell and he are joint editors of Messrs. Cassell's "Manuals of Technology," and one of the series, "Practical Electricity," already in its sixth edition, is from his pen, while, with Prof. Perry and others, he has published over one hundred Papers in the *Transactions* and *Proceedings* of the Royal Society, the Physical Society, the Institution of Electrical Engineers, &c., as well as contributing numerous articles to the technical and the general Press. His lecture on the "Electric Transmission of Power," given at the meeting of the British Association at Bath in 1888, was so much appreciated that, at the request of the town, this lecture was repeated to an audience of some 3,000, the first time in the history of the Association that one of their lectures has been repeated.

For several years the *Journal* of the Society of Telegraph Engineers was edited by him; and the present prosperous position of this Society took its start when, on his becoming the Chairman of the Editing Committee in 1878, he raised a loan of some eight hundred pounds to pay off the printer's debt and to enable the printing of the *Journal* to be placed on an economical basis.

Prof. Ayrton has been twice married. His first wife was Miss Chaplin, one of "the seven against Edinburgh," who, having been induced to spend several years at the University of that town, where they beat the men students on their own ground, were not allowed to take a degree, it being found out at the last moment that women students were contrary to the charter. She subsequently graduated as Doctor of Medicine in Paris, published numerous articles on Japan in the *Scotsman* and elsewhere, as well as a book on "Child Life in Japan," drawing many of the illustrations herself with the Japanese brush. But the great exertion connected with her medical and literary life, combined with the efforts she made throughout to improve the education and professional status of women, proved too much for her strength, for she died in 1883 at the early age of 36, leaving several unpublished manuscripts. Miss Marks, a certificated student of Girton College, Cambridge, and now a member of its Executive Committee, the friend of "George Eliot" and of the late Madame Bodichon, was married to Prof. Ayrton in 1885. The character of "Mirah" in "Daniel Deronda" is, we understand, drawn from Mrs. Ayrton; but the

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novelist has doubtless invented many of the surroundings to heighten the dramatic effect.

Among the numerous researches of a purely scientific character which have formed, together with more practical matters, the subject of nearly a hundred Papers before the Royal Society, Physical Society, and the Institution of which he is the newly elected President, may be mentioned his investigations with Prof. Perry on the specific inductive capacity of gases, the contact theory of voltaic action, and a determination of v; while as an inventor his name, associated with that of Prof. Perry, is known all over the world in connection with direct-reading electrical measuring instruments. The pioneering labours in instrument making, the design of motors, and the development of the Telpher system at a time when electrical engineering was in its earliest infancy are apt to be overlooked, because they do not occupy a prominent position in modern work; but the Ayrton and Perry ammeters and voltmeters were invaluable, even in their crudest form, and hundreds of the oldest type are in daily use at the present time. The electric meter, of which larger numbers than any other are at work in this country, and which was independently invented by Dr. Aron, was patented by Profs. Ayrton and Perry in 1881. Differential gear was designed, but the patent was abandoned, partly because none were ever sold, and partly because it seemed foolish to have to wind up a clock when a motor can be turned by a current. The patent contained a claim describing the principle of the meter, which was subsequently invented by Prof. Elihu Thomson. The winding of voltmeters, the construction of the secohmmeter and the hot-wire instruments are branches of the same subject which have more recently received Prof. Ayrton's attention. Busily occupied himself, he succeeds in living more than one life by imparting to his assistants and to his advanced students a zeal for research by setting them to work on such important subjects as the working efficiency of secondary cells, and by presenting to the scientific world the result of their investigations.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 301.*)

§ 57. **Application to the Current-Weigher.**—In this instrument the fixed and moveable coils have their planes parallel. Hence the value of M reduces to $M = G_1 g_1 + G_2 g_2 + G_3 g_3 + \ldots$ Let us make the fixed coil in two halves, at distance 2 B apart; and, as in § 49, send the current round these two halves in opposite directions. In this case, by § 54, we have, $G_1 = 0$, $G_2 = 6\pi A^2 B/C^5$, $G_3 = 0$, $G_4 = 10\pi A^2 B (B^2 - \frac{3}{4} A^2)/C^9$. Thus, when the suspended coil is at a distance b from the centre, we have,

$$M = \frac{6\pi A^2 B}{C^5} \times 2\pi a^2 b + \frac{10\pi A^2 B (B^2 - \frac{3}{4} A^2)}{C^9} \times 4\pi a^2 b (b^2 - \tfrac{3}{4} a^2) + \&c.$$

If $C = \sqrt{A^2 + B^2}$ is large compared with a and b the terms of this series soon become very small.

It is not M, however, which concerns us, but the variations of M. We find the force experienced by the small coil by differentiating M with respect to b. Thus the force per unit current in each coil is

$$\frac{dM}{db} = \frac{2\pi^2 A^2 a^2}{C^4} \left\{ 1 \cdot 2 \cdot 3 \frac{B}{C} + 3 \cdot 4 \cdot 5 \frac{B (B^2 - \frac{3}{4} A^2)}{C^5} (b^2 - \tfrac{1}{4} a^2) + \ldots \right\},$$

the expression used by Lord Rayleigh in discussing the best dimensions of a current-weigher.

Although this expression is very useful in enabling us to decide upon the best proportions for an instrument, it is not very well suited for numerical calculation. We shall, therefore, discuss some methods better adapted to this purpose.

§ 58. **Use of Neumann's Formula.**—We shall now make use of this formula to find the coefficient of mutual induction for a pair of coaxal circles. Let A, a be the radii of the circles, x the distance between their centres C, D (Fig. 50). Let any plane through the common axis cut the circles in P Q. Draw the radius D R, making an angle θ with D Q. Draw C K parallel and equal to D R, and join P K, K R, R P. Then

$$PK^2 = PC^2 + CK^2 - 2\,PC \cdot CK \cos\theta = A^2 + a^2 - 2Aa\cos\theta.$$

And $$PQ^2 = PK^2 + KR^2 = A^2 + a^2 + x^2 - 2Aa\cos\theta.$$

By Neumann's formula we have $M = \iint ds\, ds' \cos\epsilon \cdot 1/r$, where ϵ is the angle between the two elements. The angle between the element at R and the element at P is evidently θ. Thus $\epsilon = \theta$. One integration can be effected at once, for the value of $ds \int ds' \cos\epsilon \cdot 1/r$ (the element ds' belonging to the circuit Q R and the integration extending all round that circuit) is independent of the actual position of P on the circle P T. The integration round the circle P T, therefore, gives us

$$M = 2\pi A \int ds' \cos\epsilon \cdot 1/r.$$

Now, $ds' = a\,d\theta$, $\epsilon = \theta$, and $r^2 = A^2 + a^2 + x^2 - 2Aa\cos\theta$, so that

$$M = 2\pi A \int_0^{2\pi} \frac{a\cos\theta\, d\theta}{\sqrt{A^2 + a^2 + x^2 - 2Aa\cos\theta}}.$$

Having got this formula, the question arises what are we to do with it? The integral cannot be expressed in terms of any finite algebraic function. Under certain circumstances we can express the integral in terms of an infinite series, but in all cases we can express it in terms of the transcendental functions known as elliptic integrals.

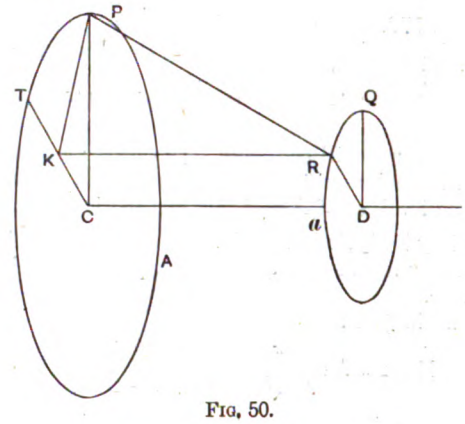

FIG. 50.

§ 59. **Series for M.**—We shall write $\rho^2 = A^2 + a^2 + x^2$ for brevity. We can write this expression in the form

$$M = 2\pi A a \int_0^{2\pi} \frac{\cos\theta\, d\theta}{\sqrt{\rho^2 - 2Aa\cos\theta}} = \frac{2\pi A a}{\rho} \int_0^{2\pi} \cos\theta \left\{ 1 - \frac{2Aa}{\rho^2} \cos\theta \right\}^{-\frac{1}{2}} d\theta.$$

So that if $2Aa$ is *small compared with* ρ^2, we can expand by the binomial theorem, and find

$$M = \frac{2\pi A a}{\rho} \int_0^{2\pi} \cos\theta \left\{ 1 + \frac{1}{1} \frac{A a}{\rho^2} \cos\theta + \frac{1 \cdot 3}{1 \cdot 2} \left(\frac{A a}{\rho^2}\right)^2 \cos^2\theta + \frac{1 \cdot 3 \cdot 5}{1 \cdot 2 \cdot 3} \left(\frac{A a}{\rho^2}\right)^3 \cos^3\theta + \ldots \right\} d\theta$$

We notice that all the *odd* powers of $\cos\theta$ vanish on integration, and that $\int_0^{2\pi} \cos^n\theta\, d\theta = 4 \int_0^{\frac{\pi}{2}} \cos^n\theta\, d\theta$, where n is any *even* whole number.

We thus find

$$M = \frac{8\pi A^2 a^2}{\rho^3} \int_0^{\frac{\pi}{2}} \left\{ \cos^2\theta + \frac{3 \cdot 5}{2 \cdot 3} \left(\frac{A a}{\rho^2}\right)^2 \cos^4\theta + \frac{3 \cdot 5 \cdot 7 \cdot 9}{2 \cdot 3 \cdot 4 \cdot 5} \left(\frac{A a}{\rho^2}\right)^4 \cos^6\theta + \right\} d\theta$$

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Again, it is well known that when n is an even whole number

$$\int_0^{\frac{\pi}{2}} \cos^n\theta\, d\theta = \frac{n-1}{n}\cdot\frac{n-3}{n-2}\cdots\frac{3}{4}\cdot\frac{1}{2}\cdot\frac{\pi}{2}.$$

Hence,

$$M = \frac{2\pi^2 A^2 a^2}{\rho^3}\left\{1+\frac{3}{2.3}\cdot\frac{3}{4}\left(\frac{A\,a}{\rho^2}\right)^2 + \frac{3.5.7.9}{2.3.4.5}\cdot\frac{5.3}{6.4}\left(\frac{A\,a}{\rho^2}\right)^4 + \ldots\right\}$$

Again, $\rho^2 = A^2 + a^2 + x^2$; therefore $\rho\, d\rho = x\,dx$ and $d\rho/dx = x/\rho$.
Hence, $d\,M/dx = d\,M/d\rho \times d\rho/dx = x/\rho \times d\,M/d\rho$.

Hence the attraction between the two coils for unit current in each is

$$X = -\frac{d\,M}{dx} = \frac{6\pi^2 A^2 a^2 x}{\rho^5}\left\{1+\frac{3.5}{2.3}\cdot\frac{1}{4}.7\left(\frac{A\,a}{\rho^2}\right)^2 + \frac{3.5.7.9}{2.3.4.5}\cdot\frac{5}{6.4}.11\left(\frac{A\,a}{\rho^2}\right)^4 + \ldots\right\}$$

Taking, as in § 47 A = 50cm., a = 10cm., x = 25cm., we have

$$\rho^2 = 3225\ A, \quad a/\rho^2 = \cdot1550388, \text{ so that}$$

$$M = 26\cdot9439\left\{\begin{matrix}1+\cdot0450694+\cdot0028437+\cdot0002036\\ +\cdot0000156+\cdot0000012+\cdot0000001\end{matrix}\right\} = \begin{matrix}28\cdot2418\\ \text{cm.}\end{matrix}$$

This approximation includes all the terms up to and including the one containing $\left(\frac{A\,a}{\rho^2}\right)^{12}$. By the rough method of § 47 we found M = 28·2491. Again,

$$X = \cdot6266236\left\{\begin{matrix}1+\cdot1051619+\cdot0104271+\cdot0010182\\ +\cdot0000988+\cdot0000096+\cdot0000009\end{matrix}\right\} = \cdot699761$$

dynes per unit current in each coil. By the rough method we found X = ·6779. The successive terms have been written down in order to show the rapidity with which the series converge under favourable conditions.

An inspection of the series for M and $d\,M/dx$ will show that if $A\,a/\rho^2$ has a value more than twice as large as in the above example, the series will converge very slowly; and that if $A\,a/\rho^2$ becomes a little larger still, the series cease to converge at all. But for small values of $A\,a/\rho^2$ this method is convenient.

§ 60. M by Elliptic Integrals.—We shall now show how to calculate M by means of a table of Elliptic Integrals calculated by Legendre.

We found in § 58 that

$$M = 2\pi A a\int_0^{2\pi}\frac{\cos\theta\, d\theta}{\sqrt{A^2+a^2+x^2-2Aa\cos\theta}}.$$

Putting $c^2 = 4Aa/\{(A+a)^2+x^2\}$ and $\theta = 2\psi$, and remembering that $\cos\theta = 2\cos^2\psi - 1$, we find

$$M = 4\pi c\sqrt{Aa}\int_0^{\frac{\pi}{2}}\frac{2\cos^2\psi - 1}{\sqrt{1-c^2\cos^2\psi}}\,d\psi$$

Putting $\psi = \pi/2 - \phi$ we have

$$M = 4\pi c\sqrt{Aa}\int_0^{\frac{\pi}{2}}\frac{2\sin^2\phi - 1}{\sqrt{1-c^2\sin^2\phi}}\,d\phi$$

$$= 4\pi\frac{\sqrt{Aa}}{c}\int_0^{\frac{\pi}{2}}\frac{-2(1-c^2\sin^2\phi) - (c^2-2)}{\sqrt{1-c^2\sin^2\phi}}\,d\phi$$

$$= 4\pi\sqrt{Aa}\left\{\left(\frac{2}{c}-c\right)\int_0^{\frac{\pi}{2}}\frac{d\phi}{\sqrt{1-c^2\sin^2\phi}} - \frac{2}{c}\int_0^{\frac{\pi}{2}}\sqrt{1-c^2\sin^2\phi}\,d\phi\right\}$$

The two definite integrals in this expression are called the Complete Elliptic Integrals of the First and Second Kinds, and are denoted by F (c) and E (c). They are simply functions of c. Thus, the First Integral is $F(c) = \int_0^{\frac{\pi}{2}}\frac{d\phi}{\sqrt{1-c^2\sin^2\phi}}$, and the Second $E(c) = \int_0^{\frac{\pi}{2}}\sqrt{1-c^2\sin^2\phi}\,.\,d\phi$.

These integrals are of very great importance in many respects. They have been calculated by Legendre, and their values will be found in Table I., Vol. II., of his "Traité des Fonctions Elliptiques," Paris, 1826. For convenience they are not tabulated according to c, but c is put equal to sin γ. The tables then give the values of log E (sin γ) and log F (sin γ), for all values of γ from 0deg. to 90deg. by intervals of 6′. The values are given to *at least* 12 places of decimals.

We can now write $M = 4\pi\sqrt{A\,a}\,\{(2/c - c)\,F(c) - 2/c\,E\}$. In both Maxwell and Mascart & Joubert this formula is given with the wrong sign. Maxwell, Vol. II., gives a table of the values of

$$\log\frac{M}{4\pi\sqrt{Aa}} = \log\{(2/c - c)\,F(c) - 2/c\,E(c)\}$$

for values of $\gamma = \sin^{-1}c$ from 60° to 89° 54′ by intervals of 6′.

As an example we will calculate, by the aid of Legendre's tables, the value of M for the case taken in §§ 47, 59.

Here

$$\sin\gamma = c = \frac{2\sqrt{500}}{\sqrt{4225}} = \cdot68801 \qquad \gamma = 43°\ 28'.42,$$

so that $2/c - c = 2\cdot218867$ $\quad 2/c = 2\cdot906888$.

From Legendre's Tables we find that when $\gamma = 43°\ 28'\cdot42$

$$\log E(\sin\gamma) = \cdot1347919, \qquad \log F(\sin\gamma) = \cdot2629611,$$

giving $M/\{4\pi\sqrt{Aa}\} = \cdot100510$, whence M = 28·24257cm., very nearly the same as we found before.

A study of the tables of these functions reveals the fact that this process is not very well adapted for the calculation of M, when γ is less than 40°, the reason being that the two quantities whose difference we have to find are then nearly equal. But these cases can generally be treated satisfactorily by the series method. It may be useful to note that if r_1 and r_2 are the greatest and least values of r, the distance between two points one on one circle, and one on the other, then $\cos\gamma = r_2/r_1$.

§ 61. Value of the Attraction.—If we wish to find the attraction between the two coils when unit current flows in each we must find the value of $X = -d\,M/dx$. It can be shown that

$$\frac{d\,M}{dx} = \frac{\pi x\sin\gamma}{\sqrt{A\,a}}\left\{2\,F(\sin\gamma) - (1+\sec^2\gamma)\,E(\sin\gamma)\right\}.$$

Lord Rayleigh gives a table of the values of

$$\sin\gamma\,\{2\,F(\sin\gamma) + (1+\sec^2\gamma)\,E(\sin\gamma)\}$$

for values of γ ranging from 55° to 70° by intervals of 6′. (See "Electrochemical Equivalent of Silver," *Phil. Trans.*, Royal Soc., 1885.)

We find that when A, a, x and γ have the same values as in § 59, X = ·699766 dynes per unit current in each coil. This is exceedingly nearly the value found by the series method of § 59.

The student who is interested in the methods of calculation will do well to find the value of M and of $d\,M/dx = d\,M/db$ by the aid of the series $M = G_1 g_1 + G_2 g_2 \ldots$ and of the series $d\,M/db = G_1\,dg_1/db + G_2\,dg_2/db + \ldots$ taking the origin, to which the Gs and gs are referred, at the centre of the small coil. With the same numerical values he will find M = 28·2426 cm. this being the sum of the terms up to and including $G_5 g_5$. Thus the three different methods which we have employed give the same value of M.

Having now explained at considerable length the methods of calculation which must be adopted to determine the value of a current from the forces which are observed to act between the different parts of our apparatus, we shall now go on to consider how Lord Rayleigh put some of the methods into practice.

(To be continued.)

THE WORK OF JOSEPH HENRY.*

If electricity can produce magnetism, may not magnetism produce electricity? Surely this was but a natural question for Henry to ask. Around the middle of the armature of his "quantity magnet" Henry winds a thin copper wire, the ends

* Abstract of Article II. of a series by Miss Mary A. Henry, appearing in the *Electrical Engineer* of New York. For abstract of first article see *The Electrician*, January 29th, p. 327.

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of which he connects with the coil of a galvanometer forty feet away. He holds the metal plates suspended over the tumbler; the assistant intently watches the distant needle. The plates are dropped into the tumbler; the electric current begins—his magnet is instinct with living power, and it *does* produce electricity in the wire around its armature; for, see—*the needle of the galvanometer swerves.* The question is answered. *Magnetism can produce electricity*, but—most important but—only at the instant of the making and breaking of its galvanic circuit. The gnome has at last been caught at work; the great problem of electrical science is solved.

There is no lack of evidence, as we shall hereafter see, to show that the experiment we have described was actually made in the month of August, 1830.

We have given it as the one by which the problem was solved; but, in fact this was not the first experiment on the part of Henry, which, when properly interpreted, demonstrated the same thing. It was in truth but a logical sequence of results which had been previously obtained. A year earlier, in August, 1829, he was in this very room testing the lifting power of his magnets with different lengths of wire. He had stretched around its bare walls one-fifth of a mile of copper wire, and had made the discovery that by connecting his "intensity magnet" with an "intensity battery," he could make the subtle electric force effective to do mechanical work at any required distance. He had, in fact, made the actual combination which constitutes the electric telegraph of to-day, wherever found and under whatever name. He made his magnet, excited by the intensity battery through that long wire around the room, ring a little bell to announce that the electric telegraph was an accomplished fact. Many times, during the busy years that followed, Henry rang his little bell by means of the electric current, for the edification of the Academy students. He was deeply interested in the experiments which led to this important result, but in the course of them a brilliant and unexpected *spark* had flashed under his eyes from a break in the circuit of a long coiled wire, with which he had united the opposite poles of his battery. In August, 1830, he had taken up the investigation of this new phenomenon, which he called "electrical self-induction in a long helical wire connecting the poles of a galvanic battery."

Many other important results were obtained, which cannot be enumerated here, but the inexorable 1st of September came all too quickly; the academic year of treadmill work; of drilling noisy boys from the rising until the setting of the sun—almost literally, since one of his classes assembled at six in the morning. And so we come down to August, 1831—the August we have dwelt upon so persistently, and very interesting it is now to see what Henry was doing, when Faraday, far away across the sea, is about to enter upon his great work. Spurred to enthusiasm by the brilliant results of the labours of the past year, Henry, to use his own words, is "making preparation for an exhaustive series of experiments upon the identity of electricity and magnetism," and is constructing for the purpose a still larger magnet. But he is not only making this larger magnet, he has constructed a great "reel" wound with a mile of wire. With the magnet we saw him using, and the wire around its armature, he had been able to move a needle forty feet away. What is he doing with this larger magnet and this great reel of a mile of wire? He is making an instrument capable of powerful work. Now look at a modern "dynamo." What is its essential feature? A reel, wound closely with wire, made to revolve within the influence of a great magnet. We do not know in what way Henry intended to revolve his reel within the influence of his magnet; but this does not matter. What he is doing in these August days of 1831 is literally *making a dynamo*, in the modern acceptation of the term. Surely, it was not too much to say that Henry was already almost lost to sight in this particular path in which Faraday is only just about to enter. But the 1st of September came too soon for the completion of his preparations. His room must be given up, as usual, for the ordinary requirements of the Academy.

The great magnet must remain unfinished, and all experiments must cease, not to be resumed until the last two weeks of June, 1832.

Prof. Silliman hears of the new magnet, and writes March 5, 1832, from New Haven to Henry:—

"I have been told that you have constructed a larger galvanic magnet than those of which notices have been published. I write to inquire if there is anything that you would like to have published in the *American Journal* for April, as to any extension or new application of your discovery. I am informed that you have applied it to the separation of fragments of magnetic iron from the mixtures of other things."

And Henry, in his reply of March 28th, 1832, says:—

"In answer to your inquiries as to my further experiments in magnetism, I have little definite to communicate at the present time. I have not entirely abandoned the subject, but have been prevented by circumstances from prosecuting a series of experiments, which were commenced on a very extensive plan. I had partially finished a magnet much larger than any before made, and have constructed a kind of reel on which more than a mile of copper wire was wound. I was obliged to abandon the experiments on account of the room in which my apparatus was erected being wanted for the use of the Academy, and it has not been convenient to me to resume them during the winter."

Other letters tell of the varied occupations of Henry's busy life, which allowed no place for the intensely interesting researches, commenced on so grand a scale and interrupted so inopportunely. They were, as we have said, resumed in the latter part of the following June. What was it that set Henry at work at that time? A paragraph in a periodical, announcing that Faraday, too, had made a great discovery that magnetism could produce electricity. The notice was brief; it showed that electricity in one wire might be made to generate electricity by induction in another wire, and it gave this experiment:—

"In a coil of wire a permanent magnet was inserted, and Faraday found that electricity was produced in the wire when the magnet was inserted in the coil, and when it was withdrawn."

Was this the experiment the one by means of which Faraday made the discovery? We shall see. It should be remembered that this notice conveyed to Henry all the knowledge he had of Faraday's efforts. It impressed upon him the immediate importance of publishing his own results. Although the notice of Faraday's experiment had been published in April, it did not come under Henry's eyes until the following June. He thereupon immediately set to work; repeated the experiments mentioned in the notice, added some others of his own, and hastily prepared a Paper for the July number of *Silliman's Journal*, giving—a fact much to be regretted—only a few of the many interesting and important results he had obtained.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-NIGHT) FRIDAY, February 5th.

INSTITUTION OF MECHANICAL ENGINEERS.

7.30 p.m. General Meeting. Papers.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert at St. James's Hall Restaurant.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Metals at High Temperatures." By Prof. Roberts-Austen, F.R.S.

SATURDAY, February 6th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Induction Coil and Alternate Current Transformer." By Prof. J. A. Fleming, D.Sc.

MONDAY, February 8th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. II.—3. "Developments of Electrical Distribution." By Prof. George Forbes, F.R.S.

TUESDAY, February 9th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be discussed: "Gold Quartz Reduction." By Alfred Harper Curtis, Assoc. M.Inst.C.E.

WEDNESDAY, February 10th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Burning Oils for Lighthouses and Lightships." By E. Price Edwards.

THURSDAY, February 11th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Paper to be read: "Some Experimental Investigations of Alternate Currents." By Alexander Siemens. Discussion on above, and "On the Specification of Insulated Conductors for Electric Lighting and Other Purposes." By W. H. Preece, F.R.S.

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The bewildering diversity which at present characterises English central-station practice will not, in all probability, be quite so prominent a feature at the end of the second decade of commercial electrical distribution as it is at the end of the first. The "drehstrom" and Mr. NIKOLA TESLA with his ideal mode of illumination notwithstanding, no fundamentally novel addition has been made within the last five years to the plant at the disposal of our electricity supply companies. Great discoveries, like great events, have a particularly awkward knack of coming to pass at the very moment when they are least expected, when the world at large has come to the complacent conclusion that such-and-such a system is utterly played out, or that such-and-such a science is no longer worthy the attention of serious men, In saying, therefore, that Dr. LODGE'S vision of the boy lighting an entire town by the turning of a handle need not be taken into serious account by anyone when planning a new central station, we do not intend to cast the slightest doubt upon its ultimate realisation, but merely mean to hint that the solution of an equation with everything unknown is not a more difficult problem than to give an entirely novel factor its due importance in everyday work. For all practical

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purposes, therefore, we may disregard this and all other similar dreams; and, doing so, it is tolerably safe to say that the visible slackening in the tide of fundamental inventions immediately affecting heavy electrical engineering is likely to increase as years go on. Side by side with this there will be a process of elimination, increasing as years go on. At present the Town Councillor in quest of the best system of electric lighting is confronted with examples of distribution by two, three, or five wires; by accumulator, alternate-current, and dynamotor substations; by alternate-current transformers in every house, not to mention the innumerable shades of difference to which the introduction of a variety of ingenious devices gives rise to. We have always sympathised with the unhappy Town Councillor in his hopeless hunt after the ideal; but have been consoled by the knowledge that at the leisurely rate of progress usual with municipal bodies the combatants in this battle of the systems will have become reduced to a minimum by the time the majority of Town Councils begin to make use of their Provisional Orders.

There is, of course, nothing surprising in the fact that so young an art as the distribution of electricity from central stations should exhibit an exuberance of methods. Every new industry is the same in this respect. Indeed, if we remember the widely-different conditions which obtain even in such closely adjacent areas as the City, the West End, and Kensington, not to mention provincial districts, anything like uniformity of practice is out of the question for the time being, if not for all time. In the matter of electric supply mains, on the other hand, it is not quite so easy to understand why electrical engineers should take delight in attacking what is almost identically the same problem all over London in so many different ways. Almost everywhere within the four-mile radius an engineer running his mains is confronted by busy and comparatively narrow streets, a soil of clay, and rubbish perforated with gas, water, telegraph, drain, and other pipes; all of which must be reckoned with, as well as the dislike of the great British public to a little temporary inconvenience and the expense attendant on tearing up roadbeds of wood or asphalt. The problem of how best to take eggs to market is a simple one; but we feel sure that if a hundred unsophisticated minds were concentrated upon it, at least ninety-nine different methods would be devised—all protected by letters patent. As it is with the egg problem, so it is with the carrying of electricity into the consumers' houses; only more so. In the multitude of systems, however, there is doubtless sufficient wisdom to justify the continued existence of perhaps two or three. Meanwhile, pending the evolution of these, the methods now in use are subjected to considerable criticism, disinterested and otherwise. Mr. X.'s culverts, we are told, only escape condemnation because they are laid in a comparatively dry soil; the iron troughs of Mr. Y., we are assured, are rapidly becoming copper-plated; while as to bitumen casing, a block weighing nearly seven pounds can actually be made to take up no less than an ounce or so of water in less than two days. Neither are those who use rubber-covered conductors and iron pipes exempt; the durability of their expensive vulcanised india-rubber cables when exposed to the vicissitudes of an underground London life is liberally discounted; while lead-covered cables in iron piping were, so we were once told, bound either to lose their lead or be coated with iron—we forget which of the two was to happen. The creosoted wood troughing recently introduced in this country is, we are informed, inimical to rubber, and the detractory remarks which the use of glass beads as insulators for electric light cables might well call forth need not be mentioned. In short, in this matter of electric supply mains we are witnessing all the ins and outs of the process by which the fittest proves its right to survive.

The type of main which perhaps commends itself most to the electrical engineer, who is, as all good electrical engineers should be, three-fourths a mechanical engineer, is the so-called "armoured" cable. Given an outer casing of steel or iron to protect from mechanical injury, an inner casing of lead to keep out chemical agents and water, together with plenty of good but inexpensive insulation, we have something which may be fairly expected to meet the exigencies of the situation. Against this type of main it may, indeed, be urged that it is not so well adapted, as some "draw in and out" systems, to cope with a gradually-increasing demand; and that jointing is a somewhat complicated operation. Only two years ago, the extent of the demand for the electric light, and the manner in which it would arise, were completely unknown factors. The same cannot be said now, so that the impossibility of adding to the weight of copper laid down without tearing up the streets is not by any means so serious a defect as it once was. Moreover, a liberal allowance of copper at the start is, from the consumer's point of view, an error on the right side. The jointing of armoured cables requiring some care, it is all the more likely that this work—of the first importance in any system of mains whatsoever—will be allotted to competent men. It will be most interesting to watch the courses adopted by the engineers of various supply companies when fresh districts are taken up, especially when such engineers have shaken themselves free from the contractors who may have promoted the companies. Serious as are the doubts which exist in some minds as to the durability of india-rubber, we believe that as soon as distinct evidence of decay is forthcoming, manufacturers will find a remedy; and every short circuit in a conduit carries with it an important hint for future work, which is not lost sight of. The resources of civilisation are not, therefore, exhausted; and, by the time that the central-station engineer has devised his last device, an electricity supply main will, in all probability, be forthcoming which will, at any rate, fulfil the not too-exacting conditions of metropolitan electric lighting.

REVIEWS.

"**Magnetic Induction in Iron and other Metals.**" By J. A. Ewing, F.R.S. (London: *The Electrician* Printing and Publishing Company, Salisbury-court, Fleet-street.)

Towards the remarkable progress which the science of magnetism has made during the last ten years no single person has contributed in a more conspicuous degree than Prof. Ewing; and no one is more competent than he is to give an adequate account of the results of recent work, so much of which is, indeed, his own. His newly published volume contains little that s to be found in the ordinary text-books. It deals almost ex iclusively with matter which has never before been published in an accessible form, and is only to be found elsewhere either buried in the Transactions of learned societies or scattered through the pages of scientific journals. Out of materials judiciously selected from these sources, and skilfully worked up into a connected and readable shape, the author has constructed a very complete digest of the modern additions to our knowledge regarding magnetic induction.

The subject is regarded throughout from an experimental standpoint, and no mere mathematical discussions, for which this branch of science offers such a tempting field, are indulged in. Such calculations as occur are for the most part of a simple character, requiring nothing more for their comprehension than an elementary knowledge of algebra, though here and there an acquaintance with the notation of the calculus is

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assumed. No systematic summary of the work can be attempted within the limits assigned to a review, but it may be useful to give an idea of the nature of its contents such as might be derived from a hasty glance through the pages.

In the introductory chapter the principal terms are defined and the fundamental ideas explained, several illustrative examples being given. Here and elsewhere the author attaches no less importance to the notion of intensity of magnetisation, I, than to the notion of magnetic induction, B. "It is not too much to say," he remarks, "that in stating the magnetic qualities of a metal the quantity I is of primary importance. The facts of saturation, the molecular theory and the phenomena of magneto-optics, all demonstrate its physical reality and its fundamental interest." In this opinion everyone whose judgment has not been corrupted by undue familiarity with dynamos will be disposed to concur. A useful feature of the chapter is an elementary discussion of the properties of magnetised ellipsoids.

The second and third chapters treat of measurements of "magnetic quality" by the magnetometric and the ballistic methods respectively. Full practical details are given, as well as a number of valuable hints suggested by the author's experience. In § 48 is an account of Lord Rayleigh's construction for correcting the curve of H and I to allow for the reaction of the specimen on the magnetising field, the rod or wire being regarded as a long ellipsoid. It is shown that even with a specimen the length of which is 400 times its diameter, the effect of the ends is by no means negligible, particularly in that part of the curve where the ascent is steepest. Among other matters of interest the chapters contain descriptions of Ewing's apparatus for demagnetisation by reversals, and of Hopkinson's application of the bar and yoke. Hopkinson's definition of coercive force is also explained.

Chapter IV. contains examples of tests made by the preceding methods. Magnetisation curves are given for various specimens of soft iron, hardened iron, cast iron, steel, nickel, both annealed and hard, and cobalt. The effects of the physical condition of the metal upon its residual magnetism are referred to, and the peculiarities of the different curves are discussed.

Chapter V. is entitled "Magnetic Hysteresis," and deals with a subject which Prof. Ewing has in a special manner made his own. If a specimen of iron, nickel, or cobalt be subjected to a magnetising force which is first raised to a certain value, F, then gradually diminished to zero, then reversed, and brought step by step to – F, then once more reversed, and gradually raised to F again, it is found that the ascending and descending magnetisation curves take two different paths, which generally enclose a space. This peculiarity indicates a tendency on the part of the changes of magnetisation to lag behind the changes of force. The same thing is observed under any cyclic variation of force, unless the range of the variation is very small indeed. "This tendency," we are modestly told, "has received the name of *magnetic hysteresis*, from ὑστερεω—to lag behind," a name which has been universally adopted, and for which, it is hardly necessary to say, the world is indebted to Prof. Ewing himself. A notable effect of hysteresis, to which, among other interesting points, attention is drawn, is that the ratio of B to H, commonly called the permeability, is by no means always the same for the same value of H. It is only under certain limitations that this ratio can be said to have a determinate value. The important practical question of the dissipation of energy through hysteresis is considered, and it is shown that the energy dissipated in a cycle is in each cubic centimetre of the magnetised metal numerically equal to the area, $\int H\,dI$, enclosed by the ascending and descending branches of the magnetisation curve. Several examples are quoted of the dissipation of energy in particular cases; thus, for instance, it appears that the horse-power consumed through hysteresis in a ton of soft iron for 100 cycles per second is 17·7. Then follow some observations as to the influence of speed and of vibration upon hysteresis; and it is incidentally mentioned that a soft-iron wire which was tapped while being magnetised had, at a certain stage, an apparent permeability of no less than 80,000.

Chapter VI. deals with magnetism in very weak fields, mostly ranging from about 0·00004 to 0·04. Within these limits κ and μ are constant, and the magnetisation curves are inclined straight lines. There is also complete absence of retentiveness. A curious phenomenon of weak fields is what the author terms magnetic viscosity, the magnetisation steadily and greatly increasing for a minute or more after the first application of the force.

Chapter VII., relating to magnetism in very strong fields, is one of the most important in the book. In it are described the experiments made by the author and Mr. W. Low, using what they call the "isthmus method," by means of which enormous values of B were reached. The present writer well remembers the half-incredulous astonishment with which the rumour was received in the rooms of the Royal Society that "Ewing had obtained an induction of 45,000 units." To appreciate this statement it must be borne in mind that, according to the opinion (based upon Rowland's researches) which was generally held only a few years ago, it was impossible by any force, however great, to push the induction in iron beyond about 20,000, and that long before this stage was reached κ would have become negative and the iron diamagnetic. The experiments, however, are conclusive, and they show that, while there is apparently no limit to the possible value of B, there is, on the other hand, a very definite limit to I, a result of the greatest theoretical importance. The saturation value of I in wrought iron is about 1,700, and is reached with a force of about 2,000 units, further increase of the force up to 24,500 having no sensible effect. An account is also given of Du Bois' ingenious optical experiments, which fully confirm the author's results; and the chapter ends with a useful table giving corresponding values of H and I for iron, cobalt, and nickel in fields ranging from 100 to 1,200 units.

Chapter VIII., which is concerned with the effects of temperature, is full of valuable matter, but is, perhaps, chiefly interesting for the account which it gives of Hopkinson's remarkable experiments. It concludes with a reference to the question first raised by Faraday—whether any metal whatever might not possibly become magnetic at a sufficiently low temperature.

Chapter IX., on the effects of stress, is a storehouse of curious and paradoxical facts, with which the future framer of a complete molecular theory will have to reckon. Among a host of other matters touched upon is the "Villari reversal," and the relation it bears to the elongations and retractions which rods of the magnetic metals undergo when magnetised.. Reference is made to some extraordinary effects of stress applied *before* magnetisation, but which may, nevertheless, be wiped out by the operation of demagnetisation by reversals; and a summary is given of Nagaoka's experiments on the effects of combined pull and torsion, which culminate in the singular result that the direction of the magnetisation in a nickel wire, which is at the same time pulled and twisted, may, in certain cases, be opposite to the direction of the magnetising force due to the coil surrounding it.

Chapter X., which deals with the conception of the magnetic circuit and some of its applications, will, unlike the last, be of interest chiefly to practical electricians. After a very full and clear treatment of the subject, the author adds this caution: "The student must not think to abandon the consideration of magnetic force and magnetisation at individual points because he finds that the notion of the magnetic circuit is remarkably useful in certain cases, and has in theory no limits to its application. Its real value lies in the fact that by its help problems which would otherwise be intractable may be solved with sufficient exactness for practical purposes." Prof. Ewing makes use of the term "magnetic resistance," to which other high authorities have objected as inappropriate and misleading. He remarks, however, that not only does the "magnetic resistance" depend upon the induction, but for an assigned value of the induction it may have many possible values; we may, indeed, have a magnetic circuit the "resistance" of which is zero, or even negative.

The final chapter begins with a sketch of Weber's well-known molecular theory of magnetism, according to which the molecules of a magnetic metal are themselves magnets, whose axes

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under ordinary conditions lie in every direction indifferently, but turn into one direction under the influence of a magnetising force. It is pointed out that while this theory harmonises well with many known facts, especially with the lately-established fact that there is a definite saturation value, some difficulty has been experienced in explaining satisfactorily a certain constraint to which the molecules must necessarily be subjected in order that saturation may not be produced by the smallest magnetising force. Weber himself supposed that each molecule was acted upon by a force tending to keep it in its original direction. Maxwell made the further assumption that, unless the magnetic force was small, the molecule, after deflection, was affected by a kind of permanent set, not quite returning to its original position when the force ceased to act. Others, again, have supposed the constraint to be of a frictional nature. After discussing these hypotheses, and indicating how they fail to accord with observed phenomena, Prof. Ewing shows that the constraint may, without any arbitrary assumptions whatever, be simply and completely accounted for by the mutual action which the molecules exert upon one another in their character of magnets. This view is amply supported both by reasoning and experiment. At p. 338 there is given a very perfect magnetisation curve, obtained in an experiment by the magnetometric method, in which instead of a bar of iron a group of 24 little pivoted magnets was employed. The three stages of the magnetising process are quite well defined; and those who have seen a similar model at the meeting of the British Association or the Royal Institution will remember how effectively it reproduces other phenomena of magnetic induction. There can be little doubt that Prof. Ewing has arrived at the true solution of a problem which has exercised the ingenuity of so many eminent magneticians. After reference to a number of experiments bearing upon the molecular theory, the chapter closes with a short account of Ampère's hypothesis of magnetic molecules.

Full of novel and important matter, the book is written, with admirable clearness, in a pleasant and easy style. It abounds with references to original memoirs for the benefit of those who may wish to pursue the subject further; and in the form of tables and curves it contains a wealth of data which cannot fail to be of value in the application of the science. It is not too much to say that no student of physics and no practical electrician can afford to be without a copy.

SHELFORD BIDWELL.

INSTITUTION OF ELECTRICAL ENGINEERS.

PRESIDENTIAL ADDRESS OF PROFESSOR W. E. AYRTON, F.R.S.

Electrotechnics.

(Continued from page 326.)

But my colleagues and I view with considerable apprehension the way in which the present wide demands for teachers in technical schools is being supplied. Several of our own students, for example, tempted by the comparatively high remuneration that is offered, have become teachers in technical schools immediately on leaving the Central Institution. In many respects they are undoubtedly well qualified; but if they had first spent some time in Works before attempting to teach technical subjects they would have better understood the wants of the persons whom they have undertaken to instruct.

No greater mistake can be made than to think that a student who has distinguished himself at a technical college can dispense with the training of the factory, unless it be the opposite mistake of imagining that the factory training is equivalent to, or even something better than, that given at a modern school of engineering.

It is the province of the manufacturer to turn out apparatus and machinery as cheaply, quickly, and as well made as possible; it is the province of the technical teacher to prepare the human tool for subsequent grinding and polishing in the factory.

And this necessity for the teacher having himself passed through the shops has especial weight when we are dealing with the technical instruction of workmen, for in such a case there are three requirements absolutely necessary—first, knowing how to teach; secondly, possessing a fair knowledge of scientific principles; and thirdly—and this is perhaps the most important of all—knowing exactly what it is that the workman ought to learn in order to help him in his particular trade.

Schoolmasters may have the first two requisites, and so may do valuable work in connection with the variety teaching at a Polytechnic; but they are not in touch with the workshop, and, therefore, no matter what may be their scholastic attainments, no matter what the extent of their experience in teaching the young, they are not the persons to give the real technical education to workmen.

In addition, then, to the polytechnics we must have special schools for special industries, where workmen are taught the application of science to their special trades; and everything taught in such a school must be taught as bearing on the particular industry which the school is intended to benefit. A teacher of physics, for instance, must remember that he is not training physicists, but workmen whose use of physical principles will be bounded by their application to their special trade; for the great danger of such teachers is that, carried away with enthusiasm for their own subject, they will not subordinate it properly to the end in view—viz., helping the workman to know what will be useful to him in his work.

Indeed, as Prof. Huxley pointed out in his original report to the Livery Companies Committee, "Success in any form of practical life is not an affair of mere knowledge. Even in the learned profession knowledge *per se* is of less consequence than people are apt to suppose. . . A system of technical education may be arranged so as to help the scholar to use his intelligence to acquire a fair store of elementary knowledge, which shall be thorough as far as it goes, and to learn to employ his hands, while leaving him fresh, vigorous, and content, and such a system will render an invaluable service to all those who come under its influence.

"But if, on the other hand, education tends to the encouragement of bookishness, if it sets the goal of youthful ambition, not in knowing, but in being able to pass an examination, especially if it fosters the delusion that brain work is, in itself, a nobler or more respectable kind of occupation than handiwork, and leads to the sacrifice of health and strength in the pursuit of mere learning, then such a system may do incalculable harm, and lead to the rapid ruin of the industries it is intended to serve."

And I venture to think that not merely at technical schools for workmen, but at technical colleges for engineers, it should be ever remembered that the main object of the training is not the cultivation of mental gymnastics, but to enable the student to acquire knowledge and habits which shall be professionally useful to him in after life.

"Useful learning usefully taught" would be no bad motto for technical institutions, seeing that those who favour the compulsory teaching of Greek are apparently willing to accept the converse as the motto for the University. For example, Mr. Butcher, in his address delivered at the end of last Session, at University College, Bangor, said:—"We may claim it as a distinction that in the seats of academic learning little or nothing useful is taught;" and in an article in last month's "Fortnightly Review," congratulating Cambridge on its recent victory over the *barbarian*, Mr Bury says quite candidly, "Greek is useless; but its uselessness is the very strongest reason for its being a compulsory subject in the University course." And he adds in italics, "*for the true function of a University is the teaching of useless learning.*"

A few of the County Councils have realised that the real teaching of the application of science to a special industry, which is what the British workman is so much in need of, cannot be given, as well as host of other subjects, out of limited funds. For example, Bedfordshire has decided to spend its grant of £4,343 mainly in agriculture, market gardening, the straw trade, domestic economy, and industries for women; Cambridgeshire and Cheshire devote themselves largely to the teaching of agricultural pursuits.

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But other places aim at issuing vast comprehensive programmes and turning out yearly a mighty army of students, knowing it may be the something of everything, but who certainly will not know the everything of something. For example, the Holland division of Lincolnshire has decided out of only £2,000 a year to make grants for dairy schools, university extension and art schools, agricultural science, domestic economy, mechanics, commercial subjects, and ambulance teaching; while Bootle, with a yearly expenditure of only the same amount, maintains classes in five commercial subjects, in 16 science and art subjects, in cookery, wood working tools, as well as four courses of university extension lectures.

Because a certain building in Regent-street famed for its ghost and its diving bell was years ago named "the Polytechnic," the majority of the new technical institutions which are being established in London at such vast cost are also called "Polytechnics," and will, I fear, give only an English polytechnic course. Now such recreative education, although admirable for those who seek relief from work in the use of their minds, is not generally sufficient for those of your workmen who use their minds in their daily occupation.

It ought, then, to be thoroughly recognised that there is an entirely new problem to be solved, and that the solution of this problem, in so far as it has been worked out at the Finsbury College, and at other places giving practical teaching in the evening, must, in the language of the mathematician, be regarded simply as "the singular solution," and not the general solution of the problem of technically educating the British workman.

Let us gratefully accept the English polytechnics, for they will undoubtedly confer benefit on our country; and all credit be to those who have so generously established them. But do not let us be misled by the similarity between their generic name and that of the German "polytechnicum" into fancying that the recreative courses of the one are equivalent to the serious education given by the other.

Like Oliver Twist, let us ask for more; for on behalf of the large number of minds already employed in the electrical industry, and on behalf of the still larger number that will in the future be so employed, it is our duty to secure that ample provision be made in this country for the practical teaching of electrotechnics on a scale comparable with that afforded in the Technical High Schools of Germany and the Institutes of Technology of the United States.

On the screen you see projected a photograph of the façade of the Technical High School at Charlottenburg (Berlin), which appears extensive and grand; and yet, as you will see from the next photograph, it was only a small portion of the whole building that you were looking at in the first photograph. This is but one of the many technical high schools in different towns of Germany, and yet *it covers an area more than five times as large as that occupied by the Central Technical Institution in Exhibition-road, London, cost four times as much to erect, and has more than four times as much spent on its yearly maintenance.*

The next photograph shows a building devoted wholly to the training of electrical engineers, being that of the Electrotechnical Institution Montefiore, at Liége, which Prof. Gerard kindly took me over this last summer, and which has since been opened. When I tell you that there are rooms for small direct-current dynamos, separate rooms for large direct-current dynamos, separate rooms for alternators, and that every three students have a separate little laboratory with the necessary measuring instruments all to themselves, your educational mouths will water as mine did.

We now cross the Atlantic to the Massachusetts Institute of Technology, Boston, which, as you see, consists of several distinct buildings, the centre one being that which contains the electrical laboratories. The dynamo room now seen on the screen has many small and large dynamos in it, and yet there is ample room to walk about; for this dynamo room occupies a space many times as large as that devoted to dynamos at the Central Technical Institution of London.

Prof. Cross was so good as to mention in a letter that was shown me some two years ago that several of the devices that had been worked out for the electrical laboratories of the City and Guilds Institute had been reproduced at Massachusetts; but there is one device that Prof. Cross has succeeded in working out, and which I should be most glad to see copied by the City and Guilds Institute, and that is, having one assistant for every five students working in the physical laboratories.

Franklin Hall, presided over by Prof. Nichols, is devoted solely to the department of pure and applied physics at the Cornell University, Ithaca. You see how large this four-storied building must be, for look how small the four-wheeled waggon standing in front of it appears.

The next three photographs show some of the provisions made for teaching electrotechnics in Franklin Hall, the electrical laboratory under Prof. Moler, and the dynamo room under Prof. Ryan, whose analyses of alternate-current curves are well known to you all.

I might show you photographs of the electrical laboratories in Prof. Weber's new building for physics at Zurich, on which £100,000 has been already expended. In fact, my choice of magnificent Continental and American laboratories has been so great that I have hardly known which to select as specimens.

But there is one thing I cannot show you—and it must remain for the exercise of your influence as representatives of the electrical profession to make that possible—the British electrotechnical laboratories for education and research, which are truly worthy of London, the capital of the world.

The training of such students as those at the Central Institution must, of course, differ essentially from that of the electrical artisan, not because we, or the students, expect that on entering a factory at the conclusion of their college course they will start, as a rule, much above the bottom of the ladder, but because they hope in time to be able to mount higher.

They are, therefore, taught not merely to construct meters and motors, use dynamos and engines, build a chimney and lay a street main, but, as they are not to spend all their lives wiring houses or watching a central station voltmeter, they are well practised in calculating and designing, and they further obtain sufficient acquaintanee with the methods of attacking new problems not to be daunted when they meet with them in after life.

But so strong is becoming our belief in the value of science to the manufacturer, so anti-classical are some of us growing, that there is great risk that the literary side of the education of an electrical engineer will soon be wholly neglected. Now, important as it no doubt is for him to be quite at home with electrical apparatus and machinery, it is no less important, if he is to take advantage quickly of the progress made abroad, that he should be able to read a German or a French newspaper. I do not merely mean that with a grammar and dictionary and plenty of leisure he should be able to translate the newspaper sentence by sentence, like a scholar preparing to morrow's lesson, but that he should have the power to glance down the columns, gather the gist of the articles, and quickly see whether there be anything new that especially concerns him.

How many electricians are there in this country who can, for example, take up the *Zeitschrift für Instrumentenkunde*, or the *Electrotechnische Zeitschrift*, and look through their pages as they do those of *The Electrician*, the *Electrical Review*, or of the *Electrical Engineer* during breakfast on Friday morning? There are, I know, a few—I wish I were one of them.

And yet examples are not wanting of the scientific isolation that is caused by not possessing that familiarity with foreign languages which is such a characteristic of diplomatists and hotel waiters. Take, for instance, the fact that whereas manganin was manufactured on a commercial scale in Germany, and German resistance coils have for the last three years been constructed of this material with a temperature coefficient of nearly zero, the very existence of this alloy was unknown to the majority of English instrument makers a few weeks ago; and even now many of them are still unacquainted with the composition of manganin, and its peculiar properties, as well as with the results of the extensive and striking experiments that have been carried out at the Reichsanstalt at Charlottenburg on the temperature coefficient and specific resistance of all sorts of manganese-copper-zinc-nickel-iron alloys.

This Physikalisch-Technischen Reichsanstalt, I may mention, is an establishment totally distinct from the Technical High

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School in Charlottenburg, some photographs of which I showed you this evening. The Reichsanstalt is not an institution with students, but a vast series of Imperial laboratories, presided over by Prof. von Helmholtz, solely used for carrying out researches in pure and technical physics. The investigations are conducted under the direction of Dr. Loewenherz, aided by 46 assistants.

We have no establishment in Great Britain at all comparable with this Reichsanstalt. The original work turned out there in electrotechnics alone is considerable. Here are some of the published accounts of researches immediately bearing on your profession, which Dr. St. Lindeck has been so kind to send me: "Hardening Steel Magnets," "Standard Resistance Coils for Large Currents," "Tests of Commercial Ammeters and Voltmeters," "Mercury Standard Resistance," "Photometric Investigations," "Compensation Apparatus for use in Potential Difference Measurements," "Alloys for Resistance Coils," and so on.

Surely it is part of the technical education of the electrical engineer to be taught how to read such pamphlets as these with comparative ease.

A working knowledge of French and German can be obtained without the necessity of learning to express oneself fluently in epigrammatic French, or to imitate with facility the word building of a native German; and with such a working knowledge the average technical student may rest content. But as regards his own language he should aim at something higher, and therefore the electrical engineering students of our own country should be, I would urge, practised in writing—yes, and also speaking—vigorous English.

Only the other day Prof. Nichols, of the Cornell University, was deploring with me the rarity of finding a student of electrotechnics who could write a decent report. The experimental methods employed in the student's investigation might have been good, the mathematical analysis suitable, and the calculations exact; but the description of the apparatus and of the results obtained would be scattered pell-mell over the paper as if the writer were quite ignorant of the fact that the style in which a dish is served up is nearly as important as the goodness of its ingredients.

Why do you suppose that Huxley's portrait has nearly as much prominence given it in the photographer's window as that of a duke or a ballet-dancer? Quite as much because he knows how to express himself in terse and forcible English as on account of his wide scientific knowledge; because, even when writing about dry bones, the flow of his language clothes them with rounded forms.

But you will ask, how are we to find the time for all this linguistic and literary polish? Has the electrical student of to-day so many spare hours that fresh subjects of study must be sought for to fill up his leisure moments?

At present much time has to be wasted at technical and other colleges teaching students 16 years or older elementary mathematics and science which ought to have been mastered before that age. When the education of childhood is improved, when the higher education of women is properly carried out, there will be no need for male experts to trouble about general training, for then children will spend less time at school and learn more; boys and girls will, as a matter of course, acquire the foundation of modern languages and general education; and students at a college will be able to devote their whole time to the special training—scientific, manual, linguistic, and literary—which pertains to the particular profession which their special tastes will generally lead them to select before the age of 16.

And just as methods of teaching applied science have been developed during the past few years, so I look forward to the growth of new methods of teaching what may be called applied literature. For it seems to me that there is a want of breadth in the view that because the study of Greek verse would be unprofitable for a student of electrotechnics, and because he has neither the taste nor the time to enter into the intricacies of etymology and grammar, therefore the study of modern languages and literature, even as directly applied to his profession, should form no part of his regular training.

As well might it be thought (and I am sorry to say this view is not yet quite exploded) that because a student has neither the taste nor the time for the study of abstract mathematics, therefore he should be debarred from all work in a physical laboratory. Well, if it be generally accepted that although a young electrical engineer has no chance of becoming a Cayley or a Maxwell, still he ought to be taught such portions of mathematics and physics as will be directly useful to him in his profession, why should the certainty that he will neither become a Jebb nor a Dickens lead us to tolerate an inability on his part to speak fluently and write tersely his own language, surpassed only by his entire ignorance of every other?

Habits of scientific thought are highly necessary for electrical students; to be masters of their own language, and to know something of one or two others I venture to think are no less so; but the main result to be achieved, the main object to be aimed at with every system of education, is moral thoroughness.

For until every workman, foreman, engineer, and manufacturer feels regret and pain at seeing work inefficiently performed our national system of education will be incomplete.

All the labour now expended in watching work in progress, and in testing it when completed to see that it has not been scamped, is so much withdrawn from the real business of production. Every rise, therefore, in the standard of thoroughness of a community means the saving of waste labour. But far greater than this will be the actual increase in the productive power when each gives his best endeavours to his share of the world's work. And greatest of all will be the gain in the nation's happiness, since he who works with his whole soul knows no drudgery.

The lesson to be taught is no new one—it was set many centuries ago; and hundreds of thousands a year will indeed be well spent if the County Councils can so succeed in bringing home to the hearts of us all this—"Whatsoever thy hand findeth to do, do it with thy might."

ON THE STRUCTURE OF A SOLID DIELECTRIC, AND THE RESIDUAL CHARGE.

BY W. A. PRICE.

The form of dielectric on whose insulating properties the most careful experiments have been made is that of the gutta-percha covering of the conducting wires used for submarine cables; and the following discussion applies principally to what occurs in the ordinary practice of testing the cores of such cables immersed in water by the method of direct deflection. In this method of testing the poles of a battery, usually of considerable E.M.F., is connected to the inside and outside conducting coatings of the dielectric; these are the conductor of the cable, and the water in which it is immersed. The currents of electricity which pass from the battery to the surfaces of the dielectric are measured on a galvanometer placed in the circuit. These currents are ordinarily recognised as divisible into two parts; one is the current which serves to charge the cable considered as a condenser, and, while at first of considerable magnitude, is appreciable only for a very short time after the battery key is closed; the other is a current which is considered to flow from one conducting surface to the other through the dielectric considered as a conductor.

After applying the battery the following events occur:—

i. A considerable quantity of electricity, which we may call the condenser charge, accumulates within a short time on each of the two conducting surfaces—+ electricity on one, − electricity on the other, the quantities being equal and very soon reaching their maximum values.

ii. The considerable flow of electricity from the battery ceases as soon as the condenser charges have accumulated, and then is observed a steady current of small quantity which appears to flow from one pole of the battery to the other through the dielectric.

iii. This small steady current regularly diminishes, at first rapidly, then more and more slowly, and finally, after a considerable lapse of time, attains a value from which no further change takes place.

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iv. On removing the battery and connecting the two conducting surfaces with a wire, the condenser charges of electricity accumulated on the conducting surfaces combine rapidly through the wire.

v. Then is observed passing through the connecting wire a small steady current of electricity in the opposite direction to the original charging current. This is called in cable-testing rooms the earth-current. It diminishes at first rapidly, then more and more slowly, and finally reaches a zero value, when the dielectric appears to be in the same condition as before the battery was originally applied.

Let us suppose the dielectric to contain a number of parts of molecular dimensions which possess always electrical polarity similar to crystals, *i.e.*, are + electrified at one end and − at the other; we suppose this electrification to be permanent and indestructible except by decomposition of the substance, and

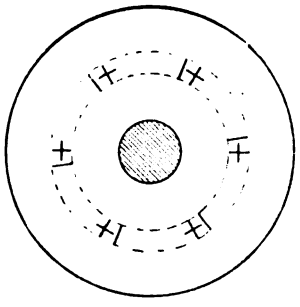

FIG. 1.—Section of cable, showing electrified parts arranged so that the lines of electric displacement form closed curves in the dielectric, giving no external evidence of electrification.

that the electrified parts are set in a viscous medium which may be a conductor of electricity as in gutta-percha, or an insulator as in glass.

From the same considerations as those which in Ewing's speculation and experiments on the structure of a magnet explain the tendency of soft iron to show no external magnetic field, it will be seen that in such a system the lines of electric displacement will tend to form closed curves of small dimensions in the substance of the dielectric, and the whole system will exhibit no external electrification (see Fig. 1), the electrified parts lying in all sorts of directions.

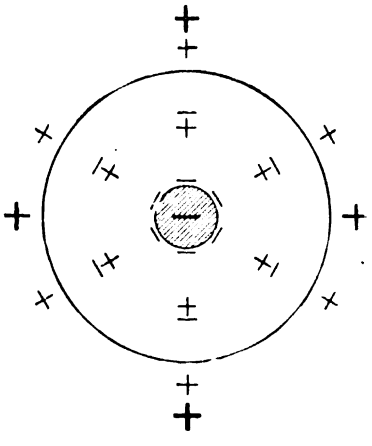

FIG. 2.—Section of cable when the electrified parts are turned by the action of the condenser charges, and induce, in virtue of their own polarity, further charges on the conducting surfaces. The thick signs represent the condenser charges.

On the application of the + and − capacity charges to the two surfaces of the dielectric, all these parts will immediately tend to set in one direction, so as to present their + charged ends to the − charged surface, and their − charged ends to the + charged one.

As each element turns in this way fresh + and − charges from the battery will accumulate on the conducting surfaces equal in amount to the charges on the faces of the terminals pre sented to them.

The elements, moreover, being in a viscous medium, will turn slowly and gradually. On this supposition, on the first application of the battery, the current, besides supplying the condenser charges, also provides the extra charges gradually accumulating on the conducting surfaces to meet the charges on the electrified elements as they gradually turn into their final positions (see Fig. 2). It may be argued from the analogous case of the magnetisation of soft iron that these additional charges will be demanded rapidly at first and more slowly afterwards, thus explaining the gradual decrease of the current. Ultimately, when the whole are turned parallel to one another and perpendicular to the charged surfaces, the dielectric is completely "electrified" (I use the term of the cable engineer), and no further action takes place. The current which continues to flow from the battery passes through the gutta-percha as a conductor. If glass is the dielectric, as in a Leyden jar, the current ceases altogether.

The earth current observed after the battery is removed is due to the gradual swinging back of the electrified elements to their old positions, or to new ones which satisfy the condition of forming closed curves in the dielectric for the lines of displacement, and thereby setting free the induced charges on the conducting surfaces.

We may notice that only with a battery of very high potential will the electrified elements be really set parallel to one another, since their positions will be determined by the resultant couple of the actions on them of the condenser charges and of the other elements in their neighbourhood.

What I have termed complete electrification is exactly analogous to the saturation of a magnet, and if it were found after the cessation of the earth current that the surfaces of the dielectric still bore charges of electricity, the existence of a property analogous to hysteresis would be established. The very slow rate at which "electrification" of a cable takes place may be compared to the "viscous hysteresis" observed by Ewing in iron.

Also we may note that on this hypothesis the dielectric resistance of a cable should be determined from the minimum value of the galvanometer deflection after the electrification is complete, and not from the deflection observed at some arbitrary interval of time after the application of the battery.

This hypothesis, then, rests on the supposition that "electrification" is due, not to any production of polarisation by expenditure of battery power, but to a direction of polarised elements already in existence. A supposition of this kind forms the bases of the at present accepted ideas on the nature both of electrolysis and magnetism.

MOTORS WITH REVOLVING FIELDS.*

BY W. RECHNIEWSKI.

By means of a revolving field it is possible to build two kinds of motors, differing largely both as to principle and performance—

1. *The Synchronous Motor with Revolving Field.*—This motor closely resembles any ordinary synchronous alternating motor. A "Brown" three-phase generator constitutes such a motor. In this motor there is a relatively powerful electro-magnet, generally with several poles, which is movable about a shaft, and which is surrounded by the revolving field. We can see easily that if such an electro-magnet turns synchronously with the field it will be carried by the latter exactly as if, in place of currents of different phases, there were an ordinary alternating current.

2. *Motors with Revolving Fields properly so called.*—In this class of motor there is no electro-magnet excited by a continuous external current; there is simply a rotating field and an armature wound with different circuits, in which the revolving field produces currents by induction; between these induced currents and the inducing currents of the revolving field reactions are produced, tending to move the armature

* From *L'Electricien, Revue Internationale de l'Electricité.* January 2, 1892.

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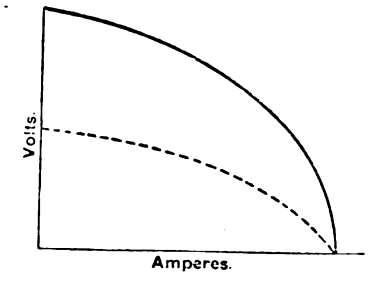
in the direction of the rotation of the field. These currents can only be produced by a difference of speed between the rotating armature and the rotating field; these motors are, therefore, necessarily non-synchronous.

The two kinds of motors are distinguished further by other properties—for instance, by that of self-induction, as will appear later on. It is possible to combine them and to construct a motor which, at the moment of starting, is actuated by the induced currents, and which, when the speed of synchronism is obtained, continues to run as a synchronous motor. I have endeavoured in the present article to make as clear as possible the reactions which take place in these motors, so as to be in a position to estimate the advantages and disadvantages of each kind of construction, to calculate the torque produced at each instant, and to see also what kind of winding is preferable on the armature in order to obtain the best results with the least possible expense. Some very simple considerations, as we shall see, give all these results without calculation, by a series of simple reasonings, and I will first consider motors with revolving fields properly so called, *i.e.*, those in which the armature is formed of circuits closed upon themselves, or upon some resistance, and traversed only by the currents induced by the revolving field. When we seek to describe the different reactions which take place in a revolving field motor—to express, for instance, the torque as a function of the speed and resistance, or of the self-induction introduced into the armature circuit—we meet with very considerable difficulties. By the method which I shall describe I take into account all the facts with sufficient exactitude, while entirely avoiding difficult formulæ or calculations. This method, which consists in comparing revolving field motors with alternating machines, allows us to apply all that we know about the latter to the study of the phenomena which occur in the former.



In a revolving-field motor there are magnetic poles of constant strength (or, at least, we endeavour to make them so) which revolve with a definite speed around an armature, which they cause to rotate with them. This armature has a certain number of closed circuits, the rotation of the revolving fields induces currents in these circuits, and it is the reaction between these currents and the movable poles of the field-magnets which produces the torque. Considering the torque only, things happen exactly as if the poles of the field-magnets were fixed, and the armature only revolved inside it with a speed ω equal to the difference between the speed of the revolving field and the revolving armature (relative speed of the armature with reference to the revolving field). Under these conditions we should have an ordinary alternating current machine revolving at the speed ω, and, as we know sufficiently well the properties of an ordinary alternating current machine, we could calculate the value of the torque in every case which might arise in practice. The torque C is equal to the total work T produced in the armature ÷ by 2π times the speed of rotation,

$$C = \frac{T}{2\pi\omega} \text{ where } \omega = \text{the speed of rotation.}$$

The work T comprises both the work produced in the windings of the armature by induction ($\int ei\,dt$) and the work lost by hysteresis; the torque C for a given speed ω will vary directly with the work T; the current can be varied by changing the resistance put in the armature circuit. But we know that the work T does not increase indefinitely when we diminish this resistance, the characteristic of an alternating current machine having a form represented by the curve shown above, and which implies that a maximum of work is given by a particular value, I, of the current, and consequently of the external resistance. The maximum torque will be obtained with this definite, easily-determined armature current. Consequently, in a revolving field motor of which the armature turns at the speed $V - \omega$, we must introduce a resistance, easily determined, in the circuit of the armature, to obtain the maximum torque of which the motor is capable when revolving at the speed $V - \omega$. We see, then, that the maximum value of the torque is the same for all armature speeds, and that it occurs when the current circulating in it has the same value, I. To obtain this value, I, we must change the resistance introduced into the armature circuit for different speeds. Let us consider the curve. If the armature turns at half speed the ordinates of the curve will be diminished one-half, so also the work T; but the maximum work will occur for the same value of the current I. We have then $T' \max = T \max/2$, but, the speed being one-half, we have the same torque.

Now let us see what takes place when a revolving field motor starts. At this moment the slip of the armature ω, *i.e.*, the difference between the speed of the armature and that of the rotating field, is a maximum. To get a powerful torque, we must have a large production of work in the armature, this work being spent partly in the armature itself, and partly in the external circuit or resistance. In order that the torque may be comparable to the normal torque of an alternating machine at full load, the work absorbed in the armature circuit must be the same; this shows the importance of a resistance at starting. If we keep the resistance constant, the work absorbed by the armature will diminish as the square of the relative speed ω; this work is proportional to $\int \frac{e^2}{R}$, where e varies proportionally with ω. The torque varying as ω, it will become much weaker at high speeds, and it will be necessary to decrease the resistance so as to keep I constant, all the resistance being finally cut out. The armature will then revolve nearly synchronously, hysteresis will be negligible, and the entire work produced in the armature will be spent in heating the windings. The work may be relatively very little, but, the difference of speed ω between the armature and the revolving field being also very small, the torque may be very effective.

We have seen that the torque is always equal to $\frac{T}{2\pi\omega}$. For an ordinary armature, the efficiency of which is 95 per cent., about 20 per cent. of the work T will be spent in the armature at the moment of starting, and the remainder in the external resistance. We could try to build a machine with very powerful electro-magnets and a very small armature, so as to diminish the reactions of the armature and avoid by this means the use of external resistance. In fact, if the reaction of the armature were nil and its resistance constant, the work T would increase as the square of the relative speed ω, and consequently the motor couple would be a maximum at the moment of starting. We do not, however, believe this is practicable for the following reasons:—

1. Because very powerful electro-magnets with much iron would be required, which implies a great loss by hysteresis.

2. The large number of turns which would have to be put upon the electro-magnets would very much increase their self-induction, and by that alone would diminish the useful effect of the high voltages which we can use with this system.

3. In order to produce at starting a torque equal to the normal torque at full speed, it is necessary that the energy spent in heating the armature at the moment of starting should be 20 times greater than the heat spent during normal work; and if, for example, the start was made rather slowly, or an unforeseen stop occurred, there would be danger of burning up the armature.

4. At starting, the field current would have to be very large (with a difference of phase from that of the armature); and there is a risk, not only of burning the fusible cut-outs if there be such in the circuit, but of causing variations in the lamps placed in the neighbourhood of the motors. In fact, to produce the same torque at starting, when resistance is not employed, a current is required in the armature four or five times stronger

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Under these conditions, the current in the field circuit increases nearly in the same proportion, and the loss by heating in the field is comparable to that in the armature. The efficiency of the motor would, therefore, be very low at starting. Self-induction in the circuit of the armature is not only no advantage, but is prejudicial according to my view; in fact, whatever be the speed of the armature, self-induction tends to diminish the work T actually absorbed by the armature and transformed into heat, and consequently to lessen the torque, which is proportional to T. We must see clearly here that the torque is not only proportional to the armature current I, which can be made more or less constant by means of self-induction, but depends also on the difference of phase between the armature and field-magnet currents. The torque, in a word, is proportional to the total work T created in the armature by the revolving field. The work T in all practical cases will be spent heating the armature and the rheostat; but it might be very easily transformed into mechanical work by another motor.

I may here make an interesting remark with reference to the work done by the field-magnet currents. Whatever be the speed of the armature, so long as the torque remains constant, by keeping the armature current I invariable by means of a rheostat, the work spent in the field circuit is constant. At the moment of starting the work is entirely spent in heating the field windings, the armature, and the resistance, and as the armature speed increases a larger proportion of this work is transformed into mechanical work, capable of utilisation on the armature shaft; but the sum of the mechanical work on the shaft and that transformed into heat on the armature is constant so long as the torque is constant. We see, then, that these motors only lend themselves to those purposes at which they will work almost always at one speed; at every other speed the efficiency will be very low.

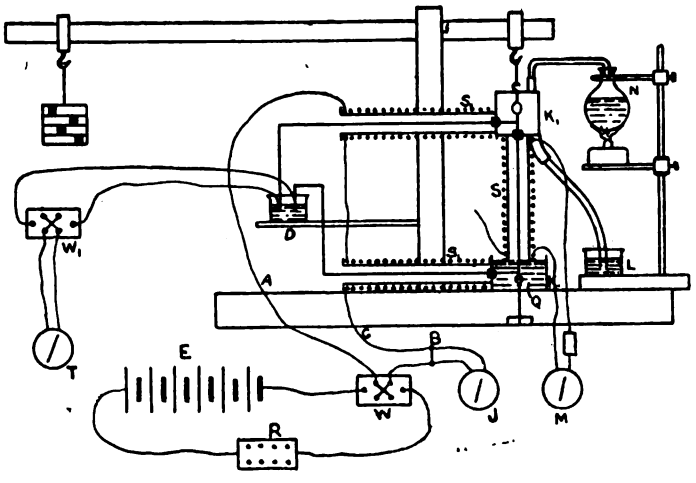
This method of considering the phenomena of revolving-field motors, and comparing them with alternating machines, is very convenient, because it tells us the best method of winding the armature so as to have maximum useful effect for a given current. The rules are the same as for the armatures of alternating-current machines. If the armature has teeth or radial projections, its rotation may become entirely synchronous with that of the field. At that moment the currents will cease to circulate in the windings of the armature, since there is no longer any difference of speed between the armature and the field, and the rotation will be maintained in a rather different manner; then the poles formed upon the teeth of the armature are attracted by the poles of the revolving field; at this moment hysteresis in the armature is strictly *nil*.

The self-induction of revolving-field motors is considerable; the changes of magnetism in each field coil are, in fact, quite comparable to those which are produced in the winding of the armature of an alternating machine of the same power.

To sum up: the advantage of the revolving-field motor over that of a synchronous alternating-current motor, such as is understood by an ordinary alternating-current generator, consists in this—that it is self-starting, and that it is not necessary to bring first the armature up to the speed of sychronism by independent means. On the other hand, it has this grave defect—the self-induction of the field magnets diminishes the useful effects of high voltages. To avoid this inconvenience we can use condensers. In synchronous motors, on the other hand, by making the magnets relatively powerful, we reduce the self-induction of the armature as low as we please. If then we desire to transmit large powers to a considerable distance, the use of ordinary alternators would appear to be preferable. The case is different if we wish to distribute electrical energy to a number of small motors made as simply as possible. The synchronous motor can be made with a revolving field, as we have already seen. We can, in fact, wind two circuits on the armature; one of these will act exactly as in the revolving-field motors already considered, and will move the armature in the direction of the revolving field; through the other circuit we can pass a constant continuous current which would produce fixed poles upon the armatures. With this arrangement the speed will increase to synchronism, as soon as that is attained; the first circuit will no longer be traversed by any current, the fixed poles of the armature will be directly moved by the revolving poles of the field and no longer by the intervention of the induced currents. If the fixed poles of the armature are very powerful, the field current will not have any influence upon their strength, so that the self-induction of the field will be *nil*, and the total voltage may be utilised for the production of mechanical work. It is evident that in practice it will be impossible to make the self-induction of the field circuits *nil*; but in all cases we can diminish it largely by using synchronous motors with powerful electro-magnets, and can also utilise the greatest part of the voltage employed, and consequently reduce the section of conductors which carry the current to almost the theoretical minimum corresponding to the voltage used. This synchronous motor with revolving field, of which the moveable part constitutes a powerful electro-magnet, will then be self-starting (with a small load, it is true), and run at full speed with very little self-induction. It will combine, therefore, the conditions of the two systems, but retain the inconvenience of a low efficiency at all the intermediate speeds between that of rest and the speed of synchronism. A two or three-phase generator can be used as a synchronous motor.

MAGNETO-THERMO-ELECTRIC EXPERIMENTS.*

It has long been known that the magnetisation of an iron or nickel wire modifies its thermo-electric properties. This fact, pointed out for the first time by Sir William Thomson,† was ascertained by forming a thermo-electric couple of two iron bars, one of which was magnetised and one of which was not. The current flowed in a different manner according as the magnetisation was transversal or longitudinal. In the former case the current flowed from the magnetised bar to the non-magnetised bar; in the latter case its direction was the reverse. Petruschewki, in 1874, and again later, in 1881, Strouhal and Barrus, repeated Thomson's experiments and confirmed the general results. The current generated, was, however, too weak for it to be possible to establish any relation between it and the intensity of magnetisation. Recently, M. Bachmetjew reinvestigated the whole question, making use of extremely sensitive measuring apparatus; notably, a Rosenthal galvanometer made by Edelmann, which enabled him to extend his researches to parallel questions, such as the influence of compression and tension on thermo-electric properties. The experimental arrangement employed by M. Bachmetjew recalls the one previously used by him,‡ the new apparatus being, however, of wood.



The metallic wire to be tested was suspended within the spiral S (*see* Fig.), 350mm. long, which was of ·8mm. wire, wound so as to give 225 turns. The *iron* wire was bent into a ring at P and Q. Above P and Q copper conductors were soldered. The end P was in a little closed brass box, insulated from the iron wire by means of an india-rubber stopper. Two other iron wires were placed horizontally at P and Q, and surrounded by solenoids S_1 S_1, similar to S. The ends of the horizontal wires terminated in a vessel, D, filled with cold water (t=10deg.). Copper conductors

* *Repertorium der Physik*, Vol. X., p. 607; also, *La Lumière Électrique* Vol. XLIII., No. 3, p. 140.

† *Phil. Trans.*, Vol. III., p. 722 (1856).

‡ Exner's *Repert.*, Vol. XXVI., p. 137 (1890).

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soldered to these iron wires led to the Rosenthal galvanometer T, passing through the switch W_1. The far end of the lower horizontal wire was also plunged into a vessel of water at 10deg. The upper muffle K, which was perfectly hermetic, was in communication on the one hand with a vessel of water heated to 100deg., and on the other with a refrigerator, L, which allowed the steam from N to condense. The magnetising current was obtained from a large bichromate six-cell battery, E, the circuit being through the rheostat R, the switch W, the wire A, the two horizontal spirals $S_1 S_1$, and then by the wire C through a small Wiedemann galvanometer, J, back to the battery. As the current was a very large one, the galvanometer was shunted at B.

The general mode of experimenting was as follows. After having allowed the vapour of water to circulate for ten minutes in K the switch W_1 was closed ; when a thermo-electric current, due doubtless to residual magnetism, was manifested. A current which was kept reversing was then passed until the opening of the circuit no longer affected the observed deflection on the galvanometer T. The circuit was then closed several times (four) in succession, the deflection being carefully observed. The value of the magnetising current was indicated by the galvanometer J, and the value of the induction current by the galvanometer M.

M. Bachmetjew, experimenting in this manner, and varying the conditions of the problem, obtained a series of numerical data, arranged in different tables, from which it follows that the thermo-electric current increases with the magnetising force, and this proportionally to the magnetising current, but somewhat slower than the square of the vanished magnetism (*magnétisme disparu*).

The iron wire employed was 1·6mm. in diameter, the temperature of the two joints being 10deg. and 97deg. The nickel wire (diameter = 1mm. ; temperature 10deg. and 97deg.) did not appear to give the same results as the iron wire ; the thermo-electric current undoubtedly increased with the magnetising current, but it was about twice as small as in the case of the iron wire, all other things being equal.

In the case of compressed and stretched wires the following conclusions were arrived at. With a constant magnetising current the thermo-electric current undergoes a notable diminution on stretching a magnetised wire, and it was possible to predict that it would be zero for a certain weight, which was confirmed by experiment. The influence of compression is not less curious. M. Bachmetjew has ascertained in fact that the thermo-electric current produced by the magnetisation of an iron wire under compression diminishes with the magnetisation when the magnetising forces are weak, whilst it increases when the magnetising forces are strong. In the case of nickel it was observed that the more the metal was compressed the weaker the thermo-electric currents, whatever the values of the magnetising forces employed.

The primary cause of these various phenomena could not be determined *à priori*. On examining them several questions naturally arise. Can magnetisation by itself produce a modification in the molecular condition of a body, and also change its thermo-electric properties ? In other words, does the molecular structure of a body vary according as the molecular magnets occupy such and such a relative position ? The results described above have enabled M. Bachmetjew to build up a theory solving this interesting problem.*

If magnetism is the sole cause of these variations in thermo-electric property, they ought to persist as long as the magnetisation. Experiment shows that this is not always so. For instance, when an iron wire is stretched and magnetised, the influence of the magnetisation on its thermo-electric properties is much weaker than when the wire is not stretched ; this influence may become zero for a certain tension, whilst its magnetic permeability increases with tension. It follows from this that the influence of magnetisation on the thermo-electric properties of iron is only a secondary influence. We must go back to a primary cause of a markedly permanent character, such, for instance, as magnetic elongation. If the variation of the length of the iron wire is the cause of the variation of its thermo-electric properties, magnetisation will be ineffectual when the conditions of the experiment are such as to preclude elongation. Now, M. Bachmetjew has proved the following thesis:—When an iron wire gives out a sound, *i.e.*, varies its length, under the influence of an intermittent magnetisation, its thermo-electric properties are influenced by the magnetisation ; but as soon as the sound, *i.e.*, the variation of length, diminishes (owing to tension, for instance) the influence of the magnetisation also diminishes, and becomes zero when the iron can no longer produce a sound, *i.e.*, no longer varies in length, under the influence of the intermittent current. From this we may conclude that the action of the magnetisation is purely secondary ; *i.e.*, that its action depends on the variation of length, *i.e.*, on the variation in the distance between the molecular magnets, and not upon their relative position. Be the molecular magnets arranged parallel or perpendicularly to the longitudinal axis of the bar, the result is the same. It follows, therefore, that the molecular magnets possess the same dimensions in all directions, contrary to Tyndall's hypothesis, which considered the molecular magnets to be longer in the direction of their magnetic axes,

M. Bachmetjew's results may be summed up as follows :—

(1) The thermo-electric force of an element formed of a bar of iron (similarly with nickel) longitudinally magnetised, and a second non-magnetised bar increases a little slower than the square of the vanished magnetism (*magnétisme disparu*).

(2) It is directly proportional to the magnetising force.

(3) It depends also upon the longitudinal mechanical tension of the magnetic wire in the following manner :—The greater the tension, the weaker is the influence of magnetisation on the thermo-electric properties of iron and nickel. In the case of iron the influence becomes zero when the metal is submitted to a certain tension. If the pull is increased the influence may even become negative ; that is to say, the thermo-electric current is reversed.

(4) Magnetisation has no effect on the electromotive force of a couple formed of stretched and unstretched iron wire, when the stretched wire no longer changes its length under the influence of the magnetisation.

(5) Compression has a certain effect on magneto-thermo-electric phenomena. It diminishes the thermo-electric force in the case of nickel, and increases it in the case of iron. When the magnetisation is very weak, compression has a weakening effect in both instances.

(6) The direction of longitudinal magnetisation has no influence on the direction of the thermo-electric current in a couple consisting of non-magnetised longitudinally magnetised iron.

(7) The thermo-electric current flows from the longitudinally magnetised to the non-magnetised metal, when it contracts under the influence of magnetisation.

(8) *Ceteris paribus*, thermo-electric properties are more strongly modified by magnetisation in the case of iron than in the case of nickel.

(9) The thermo-electric current flows from the non-magnetised to the longitudinally magnetised metal (which is contrary to what Thomson found for nickel).

(10) Magnetism does not *per se* modify the thermo-electric properties of iron and nickel, but only does so indirectly owing to the linear elongation which it produces.

* *Jour. Russ. Phys.. Chem.*, Vol. XVI., p.427 (1884).

DEVELOPMENTS OF ELECTRICAL DISTRIBUTION.*

BY PROF. GEORGE FORBES, F.R.S.

Before dealing with the subjects set down on the programme for that evening's lecture, Prof. Forbes said he wished once more to express the strong feeling he had of the great desirability of electrical engineers not slurring over the difficulties which lay in their way in regard to a cheap distribution of electricity from central stations. There were two sources of expense, viz., the cost of generation and the cost of distribution : the latter defect would cure itself as soon as the demand for current became more general ; the former could only be mitigated by careful attention to central-station details. Few people even yet realised the waste which ensued from running engines on light loads, and in heating up large batteries of boilers for a few hours' work. The employment of suitable engines and appropriate units would do much to reduce the cost of generation. The kernel of the whole matter was the "load factor," a term first used by Mr. Crompton in his Paper read last year before the Institution of Civil Engineers, and which he had defined in no less than five different ways. He (Prof. Forbes) would venture to clarify ideas by the three following definitions :—

$$\text{Machinery Load Factor for any period} = \frac{\text{Average current during that period}}{\text{Maximum current obtainable from machinery}};$$

$$\text{Current Load Factor for any period} = \frac{\text{Average current during that period}}{\text{Maximum current ever supplied from station}};$$

$$\text{Temporary Load Factor for any period} = \frac{\text{Average current during that period}}{\text{Maximum current supplied during period}}.$$

One of the first attempts at a high-pressure supply was that by means of storage batteries at Colchester, where groups of accumulators were charged in series and discharged in parallel. The scheme was not a success, the storage batteries not being reliable. An exactly similar scheme was now being tried in Chelsea. The system was a satisfactory one in many ways, the only serious objection being its cost.

Another idea of the early days of electric lighting was the multiple-series system. The five-wire system used in the Secteur Clichy at Paris was yet another way of distributing continuous currents at high pressure without allowing an unduly high pressure within the houses. The difficulty of the five-wire system, viz., the

* Abstract of Cantor Lecture II., 2, delivered before the Society of Arts, February 1, 1892.

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balancing of the circuits, had been overcome in an ingenious manner. Automatic switching of the lamps from one circuit to another was out of the question; so a "compensator," in the shape of four dynamos on the same shaft, was employed, each machine being connected to one of the four circuits. If any particular circuit received too much pressure, then the pressure on that dynamo was greater than that on the other machines, and it acted as a motor and drove them faster, raising the pressure. This device, although ingenious, was not quite satisfactory, and was going to be abandoned. All four machines required to be continually at work, and some 12 H.P. was wasted all day long in each compensator; as an alternative, batteries of accumulators might be placed across the mains.

The alternate-current transformer system was, however, the high-pressure system of distribution *par excellence*. Its convenience was enormous. The alternate-current transformer gave us the utmost facility by a most beautiful device for using high pressure without any fear of it entering the consumers' wires. The alternate-current transformer system also lent itself to accurate distribution—a point not sufficiently attended to in the past. Either by "regulating transformers" or "choking coils" at the central station we were able to regulate the pressure of our feeders to a nicety.

The alternate-current transformer had been the object of much interested criticism. It was, however, subject to certain disadvantages. The first defect was that hitherto the alternate current had not been available for driving motors. This was not so serious a drawback as it looked at first sight. Experience of places where motors had been put on to the lighting circuits was not altogether favourable to this arrangement. In many central stations indeed it had been found desirable to have different circuits for motors. The chief idea in seeking to get motors on to lighting circuits was originally to improve the load factor, but it had been found that the demand for power and light inconveniently overlapped. A second defect of alternate currents was the fact that they were not easily made available for electro-chemical work or the charging of storage batteries.

Considerable changes might be expected in our present method of distributing alternate currents. The custom of putting transformers into the consumers' houses was very costly, and rendered regulation difficult. A system of transformer sub-stations feeding into a low-pressure network was the coming thing. There was not the slightest doubt that the substations could be made perfectly self-regulating, so that the transformers might be placed in underground vaults. The gains from this method would be a diminution of the hysteresis losses and of the idle current. We might safely look for an average efficiency of 90 per cent. in our substation transformers. The feeling in favour of substations was so general amongst engineers that we might look to its universal adoption in the immediate future.

Were we working on right lines in the matter of "frequency"? He thought a radical alteration might be expected in this matter. The pioneers of alternate currents, seeing that it would be costly to place transformers of large dimensions in the consumers' houses, employed high frequencies. The result was a very considerable waste of energy by hysteresis. Now that we were all going to use substations and large transforming units, the frequencies of 130 and 80 might well be brought down to 5 or 10, *i.e.*, those in our continuous-current armatures. There were several other advantages attached to a low frequency. With the large secondary mains that we should require with the substation system, the "skin effect" would be very pronounced with our present frequencies, If we reduced our alternations it became possible to employ continuous-current motors (having well laminated field-magnets) on our alternate-current circuits. With the frequencies at present in vogue, an ordinary 100-volt motor would require another 100 volts to drive the current through the field magnets. Reduce the frequency to 5, and only 6 volts extra were required. Motors of this character were being introduced on alternate-current circuits in America, Alternate-current motors were, however, being developed in quite another direction. Nevertheless, even then high frequencies would be no gain. A low frequency would enable us by means of commutators to make alternate currents available for electro-chemical and other similar purposes. It was most desirable that at the present moment, when we were considering the question of substations and low-pressure networks, to also carefully consider the question of reducing our frequencies.

Another high-pressure system was that known as the continuous-current transformer system. In this, high-pressure currents were usually generated at a distant centre and transmitted to dynamotor substations. Owing to the armature reactions of a dynamotor or continuous-current transformer being nearly equal and opposite, the efficiency of this apparatus was extremely high. We should consider the fact that in working in this manner we are only employing the high electrical pressure as a means of transmitting energy, and that there were other means of so doing. These were the compressed air and hydraulic systems. A combination of compressed air and electricity was used in Paris by M. Popp. It was not altogether economical, but deserved more attention than had hitherto been paid to it. London afforded an example of a hydraulic supply. Here, also, the large size of pipe required was a drawback when it came to running the mains through crowded streets. A 6in. pipe, with the water at 1,700ft. pressure, could only transmit 100 H.P.

Another mode of distribution was by means of gas, special or ordinary. He (Prof. Forbes) had no hesitation in saying that in a very large number of cases it would be economical to use gas-engine substations. Gas-engines had not hitherto been made large, merely because they had not been wanted. There were, however, at present engines of 170 H.P. at work. Gas-engines were compact and economical (16 cubic feet of gas per I.H.P. per hour), and required no wasteful boilers.

Prof. Forbes concluded his lecture by a rapid glance at some of the various systems of mains in use. The insulators employed were vulcanised india-rubber, okonite, various bituminous compounds, and air. Some employed lead-covered cables, others left their conductors bare. A few years ago he had drawn attention to some most serious defects which had occurred in the lead-covered cables in Berlin and Rome, due to want of experience in manufacture and want of care in laying. Great improvements had, however, been made since then. At the Manchester (1887) meeting of the British Association he had described a system which he still thought possessed many advantages. He then proposed to use cast-iron pipes, and to run bare copper *tubes* through them, supported at intervals by porcelain blocks. At first the copper tubes alone might be used as conductors, but as the demand increased larger and larger conductors might be drawn through them. In making house connections the inner conductors need never be touched, connection being made with the outer tubes only.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January* 22, 1892.

New Western Union Office at New York.—On Wednesday last the press were invited to examine the new operating rooms of the Western Union Telegraph Company, taking the place of those destroyed by fire some months ago. The process of repair involving the practical rebuilding of the top of the Western Union building, very many improvements have been made, and the accommodation is far better than it has ever been before. The general operating rooms are on the seventh and eighth floors, each of them 75 feet wide by 200 feet long, having windows on every side. The eighth story contains the main operating room for the great bulk of the commercial business, while the floor below is devoted to special instruments of every kind, gold and stock reporters, Wheatstone transmitters, special quadruplex lines, and the like. Something like 1,200 operators are employed on these two floors. A new arrangement of switchboards has been adopted as facilitating the shifting of instruments from circuit to circuit, and the distribution of the business through the operating rooms. An automatic carrier service enables the messages to be distributed to the various operating tables from a central gallery, ann in general the arrangements for the rapid transaction of business are far better than in the old days. The fire has been a positive benefit so far as efficiency is concerned.

The Law of Hysteresis.—On Tuesday last was held the regular monthly meeting of the American Institute of Electrical Engineers, at which the principal Paper was on the Law of Hysteresis, by Mr. Steinmetz. Last summer the author conducted a long series of experiments on hysteresis under different circumstances, using, for the most part, the alternating current. The Paper was an exceedingly elaborate one, and was followed by a protracted discussion. The most useful part of it was a collection of various results in tabular form, giving a considerable array of facts regarding hysteresis that otherwise would be somewhat difficult to find.

The Electric Traction Question at Brooklyn.—The Mayor of Brooklyn has been looking into the working of the trolley system in other cities, and has found, possibly to his surprise and disappointment, that the general sentiment from the cities with which he has communicated is very strongly in favour of

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electric traction, even by the trolley system; and, in fact, adverse evidence is almost non-existent, all the protests against the trolley coming from people who are totally ignorant of its practical operation, and who would never ride in electric cars were they introduced. It is the same story that has been told of every city that has proposed such a change. The great bulk of the people universally desire it, the protests coming from a few sore-headed property owners, who ride in their own carriages and would prefer to see their fellow-citizens walk. The Mayor will probably take formal action on the resolution last passed by the Board of Aldermen this week. It is generally supposed that he will sign it, but in case of a veto the ordinance will probably be passed over his head.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *January* 30, 1892.

The electric light will be used in Christiania for the lighting of one or two of its principal streets, as soon as the central station is completed. The public electric lighting will comprise Carl Johan-street, two or three squares, and probably portions of the quay. This will necessitate about 40 arc lamps and those of about 1,000 c.p. will be adopted. It is proposed to have them at a height of 30ft. above the street, and with an interval of 200ft. The electric light will be from four to ten times more powerful than the present gas light. It is not without interest to compare the various tenders received for the Christiania central electric station, the difference between the respective offers being very considerable. The tenders were as follows:—

	Aggregate Tender.	Revised Tender.
Edison General Company	£53,290	£55,235
Crompton and Co.	47,486	45,764
Siemens Bros. and Co.	45,310	43,184
Electric Construction Corporation	34,068	44,670
Siemens and Halske	39,221	41,250
Schuckert and Co.	38,180	38,180
Thomson-Houston Electric Company	40,778	40,931
Actiengesellschaft Helios	43,113	41,391
Compagnie Continentale Edison	44,095	44,095
Kummer & Co.	32,625	32,625
Sharp and Kent	45,284	43,160
Woodhouse and Rawson United	40,580	38,454
Actiengesellschaft für Chromaccumulatoren	35,311	40,006

The above tenders were for the entire installation. On the same day as the contract with Schuckert and Co. was signed, Siemens and Halske offered to reduce their tender by £3,750, which was thought slightly out of order, as the tenders were then known, and no notice was, under the circumstances, taken of the offer. It attracted some attention that the tender from Kummer and Co., which was some £5,555 lower than Schuckert and Co.'s, was not accepted; but it was thought advisable to accept the offer from a firm which had already completed several large central station installations in preference to one from a firm which has, as yet, no experience of this kind. The cables were in both cases specified to be from Felten and Guilleaume.

Several smaller towns in Scandinavia are also going in for central electric stations. Among these is Bergen in Norway, where the installation will comprise the lighting of the principal thoroughfares, of the whole of the harbour, and of private houses. At Helsingborg in Sweden the electric central station was opened in December, the work having been very promptly carried out by the contractors, Siemens and Halske. The cable system has a length of 7½ miles, and is calculated for about 1,000 lamps. In Sorö, Denmark, it has also been decided to construct a small central electric station.

Electric bleaching was introduced in the course of last year at the Uddehalen chemical wood pulp manufactory. To begin with, only two batteries were used; but the result was so satisfactory that sufficient batteries were installed to treat the whole present output of bleached wood pulp, and electric bleaching is now the only method used at the works. A turbine works the 45 H.P. dynamo, as well as the circulating pumps and other machinery. There are now five batteries. This installation is the first of its kind in Scandinavia.

The completion of the Copenhagen electric central station has been somewhat delayed by wintry weather; but it is confidently expected that it will be able to commence operations about the middle of February. The number of customers has exceeded all expectation.

CORRESPONDENCE.

THE DETERMINATION OF THE CAPACITY OF LONG SUBMARINE CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In taking the capacity of cables by Gott's method there appears another way of arriving at the same result, without, as with, the correction put forward by Mr. Dearlove in his interesting Paper to *The Electrician* of March 6th last, if *the insulation resistance of the condenser and cable is equalised in the inverse ratio of their respective capacities.*

Taking the case, in the table below, of the cable having 280 mf., and condenser of 99 mf.,—an insulation test of each was first taken, and they gave 0·63 and 10 megohms respectively after 10 seconds charge. The condenser, to have its proper ratio of I R, had, therefore, to be reduced to 1·78 megohms by shunting. $\left(\frac{280 \times 0{\cdot}63}{99} = 1{\cdot}78\Omega.\right)$

This being done, and the slide ratio adjusted to 1000/2830, a perfectly dead-beat balance was obtained at the galvanometer, and the discharge at the junction of cable and condenser was *nil*; consequently, no correction was required, and the chance of error in reading d and d' in Dearlove's formula was avoided.

Then $1000\omega : 2800\omega :: 99$ mf. : 280·17 = capacity of the cable.

The shunt across the condenser should be adjustable, so that it can be altered in conjunction with the slide ratio to obtain the double balance.

Under precisely the same conditions (except that the condensers were not shunted), and applying Dearlove's correction, a result of 280·10 mf. was obtained.

Cable.		Standard condensers mf.	When balanced at galvanometer & dis. *nil*.		Result in mf.	By Dearlove's method.
Length in knots.	Insulation resistance.		Slide ratio.	Reduced I R of condensers.		
	Ω			Ω		
154·5	0·36	39·696	1010/1199	0·431	47·12	47·13 mf.
331·8	0·25*	59·448	1010/1660	0·414	97·70	97·33 mf.
910·6	0·63	99·000	1000/2830	1·78	280·17	280·10 mf.

* Reduced by artificial leak at home end from 2·5.

With regard to the cable of 97 mf. there is a discrepancy of 0·37 mf. between the two methods, but, considering the I R of the cable was artificially reduced by a leak at the home end from 2·5 to 0·25 megohm, the discrepancy is surprisingly small, and is due, apparently, to the fact that the increased leakage was concentrated at one point, instead of being spread over the whole cable. The result of the test of the 47 mf. cable, which has a naturally low I R, would seem to confirm this.

This double-zero method might with advantage be used as a test for localising a break in a cable where the end offers a rather high resistance, such as would occur if the G P were drawn over the conductor.—Yours, &c., F. W.

Alexandria, Egypt.

GRAPHICS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Prof. Thompson has in his letter laid down the true value of graphic methods: but will you allow me to protest against his treatment of my old friend Geometrical Conics? Having formerly taught Geometrical Conics in a public school, I have formed a very high opinion of its value as an *educational* subject. Some of the pleasantest hours I have ever spent in teaching have been to large classes on this subject. The interest of the boys is at once awakened after their dreary Trigonometry, and they begin to think that after all mathematics was not invented by a clique of Bedlamites. After a three weeks' course of Geometrical Conics, they are quite fresh and eager to attack Analytical Conics and the Calculus.

In the excellent treatise of Cockshott and Walters, and there are many others, the proofs are certainly not "long winded," and the theorems cannot always be disposed of by a "couple

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of lines of the calculus." I could give a good many theorems in which analysis comes off a bad second. A knowledge of Newton's "Principia," or of Geometrical Conics, may not be of much service to the technical electrical student, but this is no valid reason why the study of them should be banished from our public schools and universities.—Yours, &c.,

Faraday House, Jan. 30, 1892. ALEXANDER RUSSELL.

[Without wishing to raise the the question of "usefulness" of an educational subject, we must point out that in our leading article of January 27th we discussed graphics for directly utilitarian purposes for the every-day work of the man of science, but more especially for the engineer. Professor Silvanus Thompson's energetic letter last week treated the subject mainly with reference to the engineering student. "Geometrical conics," as a greased pole, may afford capital exercise in mathemetical gymnastics, and may, as Mr. Russell thinks, have a high educational value—but that is rather outside our province.—ED. *E.*]

HARMONIC ANALYSIS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was prevented from setting the following exercise to a special class which has now disbanded. The members read your paper. May I ask you to act as a medium of communication? As many others of your readers may wish to work examples in harmonic analysis I will give the simple instructions. Professor Henrici has invented a simple machine to do the work. I have taught my students how to work on squared paper, but Bottomley's book of tables will enable the work to be done sufficiently accurately.

There is a periodic function, the value of which, at every twenty-fourth part of the whole periodic time, is as follows :—

Time.	F.	Time.	F.
0	13·3660	12	3·3660
1	14·0355	13	6·9645
2	14·3300	14	5·6700
3	14·3295	15	4·6705
4	14·1340	16	4·1330
5	13·8295	17	4·1705
6	13·4640	18	4·8030
7	13·0355	19	5·9645
8	12·5000	20	7·5000
9	11·7940	21	9·3940
10	10·8660	22	10·8660
11	9·7060	23	12·2940

If T is the whole periodic time, let k stand for $2\pi/T$. Then $F = A_0 + A_1 \sin kt + B_1 \cos kt + A_2 \sin 2kt + B_2 \cos 2kt +$ &c. We have to find the values of A_0, A_1, B_1, A_2, B_2, &c. Having found them, we may write F in the shape $F = A_0 + M_1 \sin(kt + e_1) + M_2 \sin(2kt + e_2) +$, &c. If $M_1 = \sqrt{A_1^2 + B_1^2}$ and $\tan e_1 = B_1/A_1$; and so for the other amplitudes and epochs.

I.	II.	III.	IV.	V.	VI.	VII.
Time.	F	kt in deg.	Sin kt.	F × sin kt.	Cos kt.	F × cos kt.
0	13·3660	0	0	0	1·0	13·3660
1	14·0355	15	·2588	3·6324	0·9659	13·5559
2	14·3300	30	·5000	7·1650	0·8660	12·4098
3	14·3295	45	·7071	10·1324	0·7071	10·1324
4	14·1340	60	·8660	12·2400	0·5000	7·0670
...	...	...	...	...	...	...

I.	VIII.	IX.	X.	XI.
Time.	Sin 2kt.	F × sin 2kt.	Cos 2kt.	F × cos 2kt.
0	0	0	1·0000	13·3660
1	·5000	7·0177	·8660	12·1543
2	·8660	12·4078	·5000	7·1650
3	1·0000	14·3295	0	0
4	·8660	12·2400	-·5000	-7·0670
...	...	...	...	...

Rule.

Write down the values of time and F in columns I. and II. Write down kt in degrees (the last value being 345°, since 0° is the same as 360°). Write in column IV. the values of sin kt, taking care of the + and − signs. Column V. is troublesome, because each number is the product of the numbers in II. and IV. The meanings of the other columns are as stated.

Now A_0 is the mean value of all the 24 numbers in Column II.
A_1 is *twice* the mean value of all the 24 numbers in Column V.
B_1 is *twice* the mean value of all the 24 numbers in Column VII.
A_2 is *twice* the mean value of all the 24 numbers in Column IX.
B_2 is *twice* the mean value of all the 24 numbers in Column XI.

If higher harmonics than the octave are sought for, we must multiply F by sin 3kt and cos 3kt, sin 4kt and cos 4kt, &c. The work is not so very tedious as one might expect.

One of my students, Mr. Cachmaille, makes out F to be $F = 9{\cdot}966 + 5{\cdot}039 \sin(kt + 29°{\cdot}9) - 1{\cdot}053 \sin(2kt - 55°{\cdot}3)$.

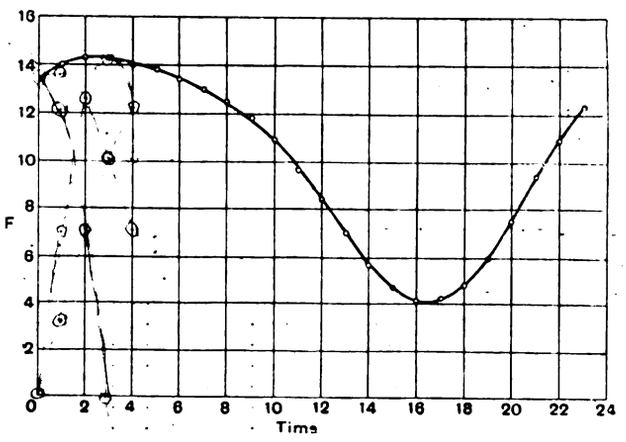
He may have made some mistakes, I do not know; but I certainly arranged that F should turn out to be

$$F = 10 + 5 \sin(kt + 30°) - \sin(2kt - 60°).$$

What I intended is not so important, however, as the true answer.—Yours, &c., JOHN PERRY.

Finsbury Technical College, Jan. 29, 1892.

[Prof. Perry's letter comes very opportunely after Dr. Fleming's article upon Harmonic Analysis of Transformer Curves; andthough the work seems rather arduous, it is extremely simple and little else than mere arithmetic. In order that our readers may appreciate the problem, we have plotted the curve alluded to from the table upon which the calculation is based.—ED. *E.*]



ELECTRIC TRACTION AND THE LIVERPOOL TRAMWAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your paragraph in last week's issue on page 317, headed "Electric Traction and the Liverpool Tramways," two errors have crept into the Chairman's remarks of the meeting of shareholders of the Liverpool United Omnibus and Tramway Company. The first is that this Company, who offered to supply electric traction to the Liverpool Tramway Company, offered the Glasgow Corporation to run their cars at 3½d. per mile by electric traction; and the second is that a comparison is drawn between 7d. per car mile for the operation of 12 cars, the number required by the Liverpool Company, and 3½d. for 100 cars, the number intended to be operated electrically by the Glasgow Corporation. The inference is drawn that the difference between the two sums is accounted for by the physical difficulties of the Liverpool streets; but 100 cars can be operated electrically for a great deal less than 7d. per car mile; and 234, the number now operated by the Liverpool Tramway Company by horses, could undoubtedly be operated for at least a saving of 1d. a mile on their present horse traction.

I think it is only fair to electric traction, and to my Company, who made the offer referred to in the paragraph, that the facts should be clearly stated; and, as we have always received the greatest kindness from the Chairman and Directors of the Liverpool United Tramways Company, we feel sure that it was not their intention to make a statement that would be misleading.—Yours, &c.,

THE GENERAL ELECTRIC POWER AND TRACTION CO. (LD.).
London, E.C., February 3, 1892. THOS. SMITH, Secretary.

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TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.

On Monday next, February 8th, will be issued the tenth annual edition of the above well-known annual, price 7s. 6d.; post free, in the United Kingdom, 8s 3d.; abroad (with the exception of a few countries), post free, 8s. 10d.

The edition consists of between 900 and 1,000 pages, and special care has been taken to make the Directorial division of the book, which has been considerably extended, thoroughly accurate and reliable.

To the Handbook division has been added several features which will be found of service to the Electrical and Allied Trades. The Digest of the Law of Electric Lighting has been thoroughly revised and brought up to date, and the most recent Board of Trade Regulations are also included. The various tables and tabulated statements relating to Central Stations, Electric Railways and Tramways, &c., have been made complete; the tables giving useful data relating to dynamos, alternators, motors, transformers, batteries, &c, have been remodelled and amplified, with the object of giving fuller particulars than hitherto relating to the principal makes of dynamos and other electrical machinery and plant. A new feature is the tabulation of valuable information respecting Electrical Limited Liability Concerns; no labour or expense has been spared to make this information complete, and we believe that this new feature will be found of great service to electrical firms having business dealings with the companies referred to. The information given respecting the Local Authorities of Great Britain has been perfected and is thoroughly reliable. An important feature of the book is the space devoted to the officials of Foreign and Colonial Governments who have the superintendence of contracts and the giving of orders for electrical plant and apparatus; and as this has been kindly supplied by the various Government departments, it can be relied upon, as can also the particulars given respecting the Home Government departments.

As our readers are aware, the DIRECTORY is due at the end of January, and, as a matter of fact, is kept posted up to within two or three days of the date of publication, as is evidenced by the inclusion of several new firms and changes of address which have only taken place at the extreme end of January, 1892.

The profession will find "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK a trustworthy work of reference, and purchasers of plant and apparatus may confidently turn to its pages for the names of all the principal firms supplying their requirements. Nearly every firm of any standing in the Electrical and Allied Trades is represented in its advertisement pages.

A digest of the contents of the book will be sent on application.

TENDERS RECEIVED.—The following tenders have been received by the Bournemouth Town Council for lighting the pier, pleasure grounds, and new municipal offices with electric light. No tender has yet been accepted:—

Barclay and Son	£6,302	7	6
Ronald Scott and Co.	5,810	0	0
Mather and Platt	5,280	0	0
	4,690	0	0
Berry, Harrison, and Co.	4,947	0	0
Goddard, Massey, and Warner	4,840	0	0
Roper's Electrical Engineering Company (Limited)	4,627	0	0
Siemens Bros. and Co. (Limited)	4,439	0	0
Laing, Wharton, and Down	4,310	16	8
Brush Electrical Engineering Company (Limited).	4,038	0	0
Woodhouse and Rawson United (Limited)	3,800	0	0
Crompton and Co. (Limited)	3,340	9	6
Johnson and Phillips	2,878	13	0
Rashleigh Phipps and Dawson	2,870	0	0
Paterson and Cooper	2,617	0	0
Fowler, Lancaster, and Co. (Limited)	2,644	0	0
	2,334	0	0
Manchester Edison-Swan Company (Limited)	1,898	0	0
J. D. F. Andrews and Co.	1,433	0	0

CHICAGO EXHIBITION, 1893.—Intending exhibitors are reminded by announcement in our advertisement columns that the 29th inst. is the date fixed for the receipt of applications for space, and that after that date applications can only be received subject to space being available.

HYDRAULIC LEAD MACHINERY.—We have received from Messrs. J. and W. Weems, Perseverance Iron Works, Johnstone, Scotland, circulars and price lists of block tin-lined lead pipe. Various hydraulic pipe presses, lead-rolling mills, and patent machinery for covering telegraph, telephone, and electric light cables, with lead sheaths, are referred to. The leading cable-making firms appear to have been supplied with lead-working machinery by this firm.

MESSRS. J. SUNDERLAND AND CO. (HALIFAX).—We have received a new price list from this firm, who are making dynamos under the Statter-Brunton, and other patents. They also supply Statter voltmeters and ammeters, medical induction coils, and other sundries. We have tried one of their medical coils, costing only a few shillings, and find that with a single cell of the General Electric Company's dry batteries, the current is more than we can stand, with dry hands.

MESSRS. PATERSON AND COOPER.—This firm have just issued Sections E and F of their illustrated catalogue. Section E is devoted to the illustration and description of electric globes, shades, reflectors, &c., and full particulars are given respecting a large variety of Messrs. Paterson and Cooper's stock of these articles. The illustrations are clearly printed in colours, and a large number of all kinds of globes and shades are shown, many of the designs being exceedingly effective. This section concludes with some more illustrations of externally cut and internally frosted ship globes, as well as a number of registered designs, both clear and frosted. Section F deals with silk and paper shades, and contains particulars of a number of very pretty designs.

MESSRS. CANNINGTON, SHAW AND CO.—This well-known firm, of Sherdley Glass Works, St. Helen's, announce that their partnership having expired by effluxion of time, they have decided to register their business under the Limited Liability Act, and have transferred it to a private limited company, which will pay and receive all debts owing by or to the old firm. This step has been taken in order to facilitate new arrangements and to admit some of their juniors. The whole of the capital will be taken up by the existing partners and their nominees.

INDIA-RUBBER ESTATES COMPANY (LIMITED) (IN LIQUIDATION).—Notice is given that a second dividend, of 2s. 6d., is payable at the liquidator's, 7, New-court, Lincoln's Inn, on any day except Saturday.

CALENDARS FOR 1892.—We have received from Messrs. Woodhouse and Rawson United (Limited) a movable calendar for 1892.

——— The General Electric Power and Traction Company (Limited) are issuing a neat hanging calendar for 1892, with illustrations.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C. from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

January 9, 1892.

487. R. E. B. CROMPTON. London. Improvements in means or apparatus for producing decorative, advertising or other effects by the aid of electricity.

491. C. A. W. HULTMAN. London. Improvements in and relating to underground conduits for electric wires.

495. G. H. ROBERTSON. London. An improved electric battery electrolyte.

499. F. M. NEWTON and T. HAWKINS. London. A new or improved dynamotor or continuous current transformer, and method of winding the field magnets of such.

January 11, 1892.

548. E. P. ALLAM. London. Improvements in holders for incandescent electric lamps.

January 12, 1892.

568. G. BUMBERG. Southend-on-Sea. Improvements in electric incandescent lamps.

576. H. D. FITZPATRICK. Glasgow. A new or improved automatic electric heat alarm. (The Electric Heat Alarm Company, United States.)

638. P. RABBIDGE. London. Improvements in telephonic switching appliances.

645. P. GENDRON. London. Improvements relating to electric welding.

January 13, 1892.

650. R. KENNEDY. Glasgow. Improvements in methods of operating alternating-current electro-motors, and in apparatus therefor.

January 14, 1892.

772. J. C. SWANNE. London. Electric shade holder.

785. E. E. RIES. Baltimore, W. S. A. Improvements in regulating sockets or fixtures for incandescent electric lamps and other translating devices, and in methods of regulating the flow of current to such lamps and other devices. [Date applied for under Patents Act, 1883, Sec. 103, July 6, 1891, being date of application in the United States.]

791. J. B. HAMOND. London. Improvements in laying and insulating electrical wires.

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798. Siemens Bros., and Co (Limited). London. Improvements in electrical conductors. (Messrs. Siemens and Halske, Germany.)

January 15, 1892.

825. W. Fairweather. Glasgow. Improvements in electric cables. (E. F. Phillips, United States.)

837. H. Hunter. Leith. Improvements in fixed or moveable electrical switch for incandescent lamps.

843. T. Coad. London. Improvements in and connected with mounting incandescent lamps for safety purposes, particularly applicable to electric miners' safety lamps.

871. H. H. Lake. London. Improvements in electric cables. (D. Brooks, junior, United States.)

875. R. J. Rae. Walthamstow. Improvements in electric lighting, and for other like purposes.

January 16, 1892.

925. A. Marr. Manchester. Improvements in telephonic receivers.

936. S. Schuckert and A. Wacker. London. An electro mechanical device for producing corresponding positions in transmitting and receiving apparatus.

January 25, 1892.

1,426. C. G. Moor. Penistone. Improvements in electrical batteries.

1,436. J. Y. Johnson. London. Improvements in friction driving gear for dynamo-electric and other like machinery. (A. de Bovet, France.)

1,442. T. Parker and J. Wakefield. London. Improvements in the manufacture and production of electro-plated metal sheets or articles.

1,459. W. White, J. Radcliffe, and F. W. Cooke. London. Apparatus for adjusting commutators of dynamo-electric machines and motors to varying speed.

1,464. T. Jenner. London. Improvements in holders or sockets for incandescent electric lamps.

January 26, 1892.

1,484. J. B. Entz and W. A. Phillips. Manchester. Improvements in and relating to secondary batteries.

1,497. A. Shiels. London. Improvements in couplings for electric wires.

1,557. R. Threlfall. London. Improvements in electro-magnetic apparatus for producing a reciprocating motion, and for supplying intermittent electric currents for that purpose.

1,580. S. M. Mathews. London. An improved electric low-water alarm.

January 27, 1892.

1,626. R. G. Evered. London. An improvement, or improvements, in the holders or carriers of electrical incandescent or glow lamps.

1,641. A. Siemens. London. Improvements in electro-motors for electrically propelled vehicles.

1,656. J. Y. Johnson. London. Improvements in electric brakes. (A. de Bovet, France.)

January 28, 1892.

1,665. G. Coles. Bristol. Improvements in electrically-operated means for preventing railway collisions.

1,682. O. Firth. Bradford. Improvements in electrical arc lamps.

1,695. T. Parker and W. Armistead. Wolverhampton. Improvements in instruments for the measurement of electromotive forces.

1,731. J. von Peichl. London. An improvement in electric compasses and course recorders.

1,737. A. J. Boult. London. Improvements in electric clock mechanism. (F. A. Ellis.)

January 29, 1892.

1,746. J. Howard. Dublin. Howard's magnetic carrier.

1,748. Eugen Conrady and G. W. Brown. Keighley. Improvements in dynamo-electric machines.

1,786. R. Pinna. London. Improvements in or relating to tanning by electricity.

January 30, 1892.

1,829. M. Sutherland. Dumbarton. A portable electric planing and polishing machine.

1,852. H. Raison. London. Improvements in apparatus for registering electric and other currents.

SPECIFICATIONS PUBLISHED.

1891.

2,518. Gibbings. Electro-depositing. (Price 8d.)

3,553. Thompson. (Reed). Electric railways. (Price 8d.)

3,893. Glover and Preece. Electrical cables. (Price 8d.)

3,957. Miller and Woods. Measuring electricity. (Price 6d.)

4,120. Fryer. Electric incandescent lamps. (Price 8d.)

12,985. Annesley and Others. Electric railway signalling. (Price 8d.)

14,385. Dymond. (Gutmann). Electric motors. Price 8d.)

16,870. Sutcliffe and Atkinson. Dynamo electric machines. (Price 6d.)

17,731. Linders. Electric motors. (Price 6d.)

17,732. Linders. Electric motors. (Price 6d.

21,442. Lake. (Roberts.) Secondary batteries. (Price 4d.)

21,448. Pitt. (Böhm.) Incandescent lamps. (Price 6d.)

21,449. Howard. Electrical switches. (Price 6d.)

COMPANIES' MEETINGS.

Anglo-American Telegraph Company (Limited).

The ordinary half-yearly general meeting of this Company was held at Winchester House, Old Broad-street, on the 29th ult., under the presidency of Mr. Francis A. Bevan.

Mr. J. C. SMITH read the notice convening the meeting, in the absence of the secretary (Mr. T. H. Wells), who was absent through illness.

The CHAIRMAN then said: My first duty in addressing you this afternoon is to express my regret that our Chairman (the Marquis of Tweeddale) is, unfortunately, prevented from taking the chair as usual, owing to illness. We have also to regret very much what we have heard respecting another Director of this Company, our old and valued friend, Mr. Cyrus Field. I am sure I am expressing the feelings of this meeting when I say that we heartily condole with him in the great trouble which has come upon him towards the close of his life, and we earnestly wish that he may yet be restored to health and strength. We can never forget that it was mainly owing to Mr. Field's skill and pertinacity that Atlantic telegraphy was ever successful. In spite of repeated failures, Mr. Field saw carried to a triumphant result the idea which he had so much at heart. Now, gentlemen, I can quite understand that on reading this report there might have been a certain amount of disappointment at the result of the year's working. When we look into the accounts we find there is almost no increase in the receipts, but I may explain that of the increase of £5,000 odd, about £1,000 was really a matter of account, and that the real increase in the receipts of the half-year was only £1,500 beyond this £4,000 that I am speaking of. I do not know that we can be greatly surprised at this, when we take the state of business into account. I have seen the figures of the Bankers' Clearing House returns for the year. I do not think I am at liberty exactly to mention them before they are published, but when they are published you will see that there has been a falling off in business during the past year of many hundreds of millions as far as the Bankers' Clearing House returns are concerned. That, perhaps, is as good an indication as you can possibly have that there has been much less business transacted during the past year than during the previous year. We know to what this is principally to be attributed—the Baring crisis. We could hardly expect in this state of business that we should be able to maintain the same amount of business as in the previous year, but I am glad to say we have not only maintained the receipts, but they are a little larger than in the corresponding half of the previous year. The increase of expenses is owing to two causes. First of all, we have had to open new stations, in order to meet the competition, which is a very powerful competition; and you know in these days unless people have telegraph stations brought almost to their very doors, it is a question whether they will telegraph at all. We have, therefore, spent some thousands of pounds in establishing new stations, a policy which, I am sure, you will all approve. Besides that, we have had to spend rather more than usual on the repairs of cables. As you see in the report, "the Company's ss. 'Minia' has been engaged during the past half-year in the repair of the 1880 cable, the Brest St. Pierre cable, the North and South Placentia cables, and the Duxbury cable," whereas in the previous half-year we had very few repairs; so that we have had not only to open these new stations for the development of our business, but also to spend more than usual upon our repairs. The result is that the amount available for dividend, I regret to say, is rather less than it was for the previous half-year. But let me just throw a little ray of light upon what appears a rather dark statement. I am glad to say that the new year has opened better. We are able to report that from the 1st to the 28th of this month there has been a daily increase of £50 in the receipts, and if business will only become better, no doubt we shall share in the good results that are sure to ensue. Perhaps, here I may just allude to the latter part of paragraph 4, in connection with the Company's cables. You will see there that the "Minia" has been employed in laying a cable from North Sydney, Cape Breton, to Canso, Nova Scotia, which means 116 miles of new line, to make a most important connection. It brings us into more direct communication with New York than before, it completes the through cable communication between England and New York city; and we have not taken this out of ordinary revenue, but we propose, with your sanction, to take it out of the renewal fund. We have no capital account to which we can debit the amount, and we must ask your permission to debit this amount of £12,000 to the renewal fund. It appears to us that no more legitimate use can be made of the renewal fund than such an expenditure as this. We, therefore, believe that you will be very glad to sanction such an expenditure on account of the renewal fund. I can easily understand that there is a certain amount of disappointment with regard to the dividend, and the Chairman has received letters suggesting that we should increase this dividend by taking something from the renewal fund. It appears to me and my colleagues that this would not be a wise proceeding, and I venture to say this for reasons which I will now mention. In the first place this renewal fund is the very backbone of our Company. If it had not been that we had this large fund behind us when we had that competition with our rivals, I do not know where we should have been. But, more than this, you must recollect that we have now four cables, all of which are rather old. One was laid in 1869, one in 1873, one in 1874, and the other in 1880; and, in case of any serious breakdown, the only source from which we can repair or renew is the renewal fund. At this moment our Brest cable is broken in deep water something over 1,000 fathoms. We cannot say how much it will cost us to repair that cable; we cannot say even whether we can, though probably we can; but I want to ask you to suppose that one of our cables was to be broken and we could not repair it, where are we to get the money to put down a new cable except from this renewal fund? Surely it would be most unwise to whittle away this renewal fund for the purpose of in-

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creasing our dividends when we have these old cables, and giving to our shareholders that which that they have not really and fairly earned during the half-year. I maintain that that would be an utterly unsound and unwise policy, and that we should not be fit to be Directors of this Company if we were to adopt such a course. Suppose, as was suggested at the last meeting, I think, that our dividend were to be fixed at 3½ per cent., and suppose that we paid such a rate on the present occasion, it would mean taking rather less than £60,000 out of our renewal fund, which we could never get back again, and this in the face of what I have just now stated. I do trust that you will take this into your serious consideration. We must look at the security and safety of our lines. Upon them depends our power of earning, and if we in any way were to risk that we should for ever regret that we parted with money which we could not possibly get back again, and which we have found before, and shall still find, most invaluable. There is just one other point I should like to mention in connection with this rate of dividend. I shall only touch lightly upon it, but it is an important point. We hear sometimes that we compare very unfavourably with our rival, the Commercial Cable Company. We see that they pay a dividend of 7 per cent., that they pay off a large amount of debentures, and put a certain amount to renewal fund; and at first sight gentlemen say, "How is this; how is it that one Company can pay such a high rate of dividend, while the other pays such a small rate?" Well, gentlemen, I do not think that the reason is very difficult to find. Some of us have been in this Company for a great many years—some of us from its inception—and we remember that, notably in 1873, when this Company took over the Newfoundland Company and the French Company, as it is commonly called, a certain amount of bonus stock was created, with the full concurrence of the shareholders, and, as it seemed at the time, wisely; but we cannot forget that the result of that is that we have to pay a dividend not only on the amount in sovereigns that you have invested in this concern, but also on a large amount of capital that has not been invested at all, and that if the real capital of the Company was what the market value says—which is, I believe, about the fair value—instead of paying £2. 12s. 6d. per cent., we should now be paying at the rate of 5¼ per cent. Now, I hope you will take this into consideration. We are certainly overweighted with our capital at present, and we are put in a position of having to pay on a very large capital as compared with that of our rivals; and therefore I say that the comparison, after all, is not so unfavourable, especially when you take into account the further fact that the Commercial Company have two new cables, which do not require the repairs that are necessary in old cables, and that they have an enormous "pull" on the other side from their connections in America. All their affairs, too, have been conducted with great zeal. In view of all these facts, I am not, after all, so despondent when I see them pay a much larger dividend than we do, for I say that our dividend is in reality much larger than appears on paper. Now, gentlemen, as to the future, all that your directors can do is to endeavour to maintain these cables in a state of efficiency, and, as far as possible, to organise their work properly. We have been giving special attention to getting the messages transmitted as correct as we can. As I have said, we have been opening new stations, and thus trying to obtain more traffic. We cannot, however, create traffic; we cannot make people send messages who have no reason for doing so. All that we can do is to try and get as many messages as possible by fair and legitimate means, and to maintain our undertaking in a proper condition. This we shall try to do; but I hope that we shall not be asked to pay a dividend which we have not earned, and thus try and give a false impression to the market. In my opinion though, if the market were to see that we were paying a dividend, as has been suggested, out of the renewal fund, we should see the stock fall instead of rise. I do not know that I have anything more to say to you. This is the first time I have addressed you, and I hope you will excuse anything I have said wrongly or out of place owing to want of experience. All that I can suggest to you is that you should do all that you can do to help us. I believe that if our shareholders were as much as possible to try and influence traffic to come to us, they would do something materially to help us. We have a great number of shareholders, and I daresay a good many of them send messages. They also have friends who send telegrams across the Atlantic. If this Company is to be really more of a success it is by our all pulling together. We have all got the same interest in trying to secure more traffic, which means a larger dividend. He concluded by moving a resolution for the adoption of the report and the payment of the dividends referred to therein.

Sir JAMES ANDERSON: I have great pleasure in seconding the resolution.

Mr. SMITH (York) said that the proprietors were much obliged to the Chairman for the observations he had made, but he thought that they were not upon the point which the proprietors would have liked to hear about. He wrote to the Directors on December 28th suggesting the payment of a dividend of 3½ per cent. per annum, but he had no idea at that time that their traffic would turn out so unfavourably. They were now paying the same dividend as was paid last year.

The CHAIRMAN: Last year we paid £2. 17s. 6d. per cent.

Mr. SMITH, continuing, said that he had thought the dividend was the same, but after what the Chairman had said the position in regard to this important point was even worse than he had thought. He wished to know the amount of new business which the new stations had brought to the Company. The Chairman had told them that the Company had established direct communication between England, France, and New York, and that should show some increase of traffic. He had no doubt that if the increase in their receipts went on at the rate of £50 a day they would be able to pay an increased divivend—at least, he hoped so.

A SHAREHOLDER said he thoroughly agreed with the Chairman that it would be most unwise to take any sum out of the capital of the reserve fund, as had been proposed by the last speaker. At the same time, he did not see why the interest on the £1,000,000 of investments forming the reserve fund should not be brought to the credit of revenue, as was generally done in the case of other companies. He supposed that the £12,000 spoken of by the Chairman was already charged against the renewal fund, and in that case the proprietors now had only to approve the course which had been taken by the Directors. He hoped that with the improvement in their receipts since the beginning of the year the shareholders might anticipate receiving a little more.

Mr. CHESTER observed that the renewal fund had been for years so much deducted from the income of the Company, in consequence of which a reduced amount had been paid on their Ordinary stock, while nothing had been paid on the Deferred stock. It had been taken from the revenue of the Company from year to year, and Lord Monck had frequently stated that as soon as the fund amounted to £1,000,000 it should be stopped.

A SHAREHOLDER: That is never done in any Company.

Mr. CHESTER, continuing, stated that the securities of the reserve fund were shown at their cost price of £923,500; but he found by the share list that these securities were worth £973,500. He found that, deducting the amount at the credit of the renewal fund, they only paid a dividend upon £2,200,000.

A SHAREHOLDER: That is the present price of the stock.

The CHAIRMAN: But we have to pay on the larger amount.

Major BIGGE said he understood that the Commercial Cable Company earned 13 per cent. on its capital, although it paid a dividend of only 7 per cent., the remaining 6 per cent. being carried to reserve fund or set aside to redeem its debentures. He supposed that the capital of the Anglo-American Company, before it was "watered," was about £3,500,000, on which 3½ per cent. was paid. He was quite opposed to taking any of the renewal fund for paying the dividend.

Mr. JOHN NEWTON asked whether there was a known example of a modern cable being unrepairable. Was there also a depth at which any of their cables were laid which had prevented them from being picked up with the greatest ease. He did not think that any statement should go forth from their meeting that day to indicate that their cables were not as safe as a railway.

Mr. W. W. THOMPSON stated that he had been at several of the meetings of the Company, and he believed it would be in the recollection of many that their Chairman had said that when the renewal fund came to £1,000,000 it should be closed, and that the interest arising from it should then come into revenue. If that were so, the holders of the Deferred Stock viewed with some surprise the action of the Directors in employing the fund, immediately it amounted to £1,000,000, upon work which, as he held, the fund was not intended for. He maintained that the word "renewal" did not cover the construction of new cables. The Chairman had told them that day that the Company's cables were old compared with others laid in the Atlantic, and, that being so, he considered it all the more reason why the renewal fund should be kept in hand for repairing them when the necessity arose.

A SHAREHOLDER said he quite endorsed what the last speaker had stated—that the shareholders had been informed by the Directors that when the reserve fund, or the renewal fund, amounted to £1,000 000, the interest arising from it should be used for the benefit of the Deferred Stock.

A SHAREHOLDER: For dividend purposes.

A SHAREHOLDER said that he regarded £1,000,000 as quite sufficient for their purposes, especially in view of what had been said as to the perfection with which cable laying and repairing were now carried out. He inquired what was being done in regard to the lawsuits that were going on.

The CHAIRMAN: I will endeavour, as far as I can, to try and answer some of the questions which have been asked The first gentleman who addressed us was Mr. Smith, who, I am very glad to see, has not moved the resolution which he proposed to bring forward, and I feel that that is an act of kindness on his part. He asked how much business had been brought to the new offices, and the traffic we had gained in Belgium and elsewhere. It is very difficult to ear-mark the traffic, but if we could do so, as we can at the offices, it would not be wise to publish the information at a meeting, because if we had gained at any particular place it would only induce our rival to redouble their efforts there. I daresay Mr. Weaver could enlighten us, but I feel sure that you would not wish me to tell you, if I could, the amount of traffic we have gained at any particular new office. Another point raised by several gentlemen was with reference to the remarks I made about the "life" of cables. Now, this is a very difficult question. Mr. Newton spoke of modern cables. I do not quite know what he meant by modern cables—how far back he calls a modern cable. All cables, in one sense, are modern, but no doubt improvements have lately been introduced, and the probability is that the later cables are better constructed than the older ones. As to the older cables, however, I must remind the meeting that, so far from our cables lasting for ever, three of the cables we originally laid have so far perished that we are not making use of them, and that they are beyond repair. As we have only existed since 1866, and as three of our original cables have gone, I think we should bear in mind that it would not be safe or wise to say that our cables were as durable as the iron roads mentioned by Mr. Newton. We believe, and we can see from experience, that, generally speaking, these cables can be picked up and mended; but sometimes they cost a great deal of money. I daresay you will remember that in the case of one cable that we picked up it cost us £90,000 to do so. I should be very sorry to depreciate our property in any way, but it would be unwise to treat cables at the bottom of the sea as we treat iron roads on dry land. Mr. Smith spoke of our expenses. I do not know whether he knows how many men we employ, but we have a staff of some 300, exclusive of messengers, and many of these men have necessarily to be rather highly paid, because they must be scientific men and men with a certain amount of experience. I do not think that anyone

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who conducted these cables could do so much more cheaply than we. I was sorry to hear the remarks he made rather depreciating the services of Mr. Weaver. If there is any man to whom this Company is indebted it is my friend Mr. Weaver, and I confess that it was with pain I heard one of our shareholders hint that Mr. Weaver's services are too highly remunerated. Mr. Weaver has given his help, his strength, his time, ability, and skill for the benefit of the shareholders; and I am extremely sorry that any remarks should have been made tending to depreciate Mr. Weaver's services. Respecting the renewal fund, a good many remarks have been made, and I must be somewhat careful what I say on this point, because everything that a Chairman says with reference to this matter is evidently remembered, treasured up, and recorded, so that it comes up at a later meeting in case he makes a slip. You have spoken about the interest of the renewal fund being added to that fund. Now, during the last four years that fund has been credited with £30,000 a year for interest, making £120,000, but during the same four years it has been debited with £20,000 a year, or £80,000 in all; and, therefore, during the last four years the fund, instead of increasing, as you might imagine, by the whole amount of the interest earned, has really only increased by £40,000, the remainder of the interest having been applied to renewals. I think this statement will show you that the Directors have not been adding to this fund in the hand-over-hand style which might at first be imagined. We have only had £10,000 a year really to add to the fund. As to the value of the fund itself, surely you would not wish us each time we come before you to give you the market value of the fund on the day. The actual market value of the investments constituting the renewal fund on December 31st, to which date the report goes up to, was about £40,000 more than the cost price, at which we have put them: and they have increased, according to Mr. Chester's calculations, by another £10,000 in the last 28 days. He may be perfectly correct, but we cannot say whether it might not be largely depreciated by some great catastrophe in the next two or three months. It would not be wise—it would be inconsistent with the principles of business, to show our stocks always at the market price of the day. We have taken them as a whole at cost price, and have not written them up by £40,000 or £50,000 of nominal value. In calculating this fund, too, we must remember that some portion of it is cable, and I do not think that that ought to be taken into account. The renewal fund, however, amounts to something like £1,000,000; we admit it, and it is quite an open question whether, when the fund has fairly reached the million, we should not give the shareholders the benefit of the interest. Mind, I say it is an open question. I am not going to pledge myself or the Directors on the point. I have been looking to see what former Chairmen have said, and I find that Lord Monck said that when the fund reached £1,000,000, no more should be taken from the receipts and put to it. He was not then, however, as far as I can tell, speaking of the interest of the fund. I am quite sure that when in our opinion the fund has fairly reached the million we ought to consider and do what we can to give the shareholders the benefit of the net increase which occurs thereon; but please to remember that that has been only £10,000 a year in the last four years. It is not the whole interest of the fund, but the interest subject to reductions for renewals.

A SHAREHOLDER: Renewals and extensions.

The CHAIRMAN: Now I come to that question of extensions. It has been said that the renewal fund was not intended for extensions, and the auditors put in their certificate, "Audited and approved, subject to the above charge of £12,141. 19s. 2d. being confirmed by the shareholders." It was their opinion whether, without the consent of the shareholders, this amount could come out of the renewal fund. If, however, it did not come out of that fund, it could only come out of the balance available for dividend, as we have no capital at all. I do not know what we should gain by carrying this sum to a suspense account. That is a course that is taken when there is an expectation of getting something back; but there is nothing to come back in regard to this outlay. We think that we have acted in this matter for the benefit of the concern generally; and considering that we have this large renewal fund, which some gentlemen are very anxious to get for the benefit of their own pockets, we do really give them the benefit of the fund by expending this money to improve the traffic between the London and New York. Mr. Chester made some remarks which I cannot follow as to the capital value which he had arrived at of the whole property. It is perfectly open to anyone to say that our capital value is £2,200,000; but, if so, we are paying a very high dividend. I believe, however, if our property were sold it would realise far more than this sum, and that that is by no means the value of our property. He also asked about the amount standing on deposit account. That is in hard cash, placed at the bankers for the purposes of meeting your dividend. We have from time to time large out-payments to make, and it seems to me a very small amount to have at your bankers to meet your dividends and any other expenses you might be called upon to bear. With regard to the action in Paris, Mr. Chapman, our solicitor, is here, and I will ask him to reply to that question, as he will be able to do so better than I can.

Mr. CHAPMAN stated that the case in the first instance was heard before the Tribunal of Commerce, whence it went on appeal by the French Company to the Court of Appeal in Paris. The Court of Appeal in Paris, before pronouncing any judgment upon it, remitted the matter to the administrative department, in order that the real meaning of a letter of the Minister of the department which was addressed to the French Company might be interpreted. The decision of the Conseil d'Etat was given last May, and there was no appeal from it. The effect of the decision was to send the case back to the Court of Appeal in Paris, and the case was now pending in that Court. It was hoped, however, that it would be shortly settled.

A SHAREHOLDER: Will that be final?

Mr. CHAPMAN replied that there was the Court of Cassation, which was the highest Court in France on certain points, but whether that Court would be appealed to or not he could not say.

Mr. CHESTER said that he saw it stated in the newspapers that the decision which had been given was final.

Mr. CHAPMAN replied that the decision of the Conseil d'Etat was final, but that was only interpreting the true meaning of the letter of the Minister. No decision had been given on the merits of the thing.

A SHAREHOLDER inquired the amount involved in the case.

Mr. CHAPMAN said that this was a question which it would be impossible for him to answer. The Tribunal of Commerce gave 2,000fr. a day for one period, and 5,000fr. over another period, but the Court of Appeal in Paris was not bound in any way by the decision of the Tribunal of Commerce. The judgment of the Tribunal was on the assumption that the French Company would resume, sooner or later, the performance of the contracts, but they might look upon this now as not at all likely.

Mr. SMITH desired to state that in what he had said about Mr. Weaver he had only been making general remarks on that gentleman's position as Managing Director. He had intended nothing personal in what he had said. The expenditure for the past year was about £5,000 more, and this subject was under Mr. Weaver's control.

The CHAIRMAN, resuming, said: Some one spoke about Lord Tweeddale's energetic management of the North British Railway Company, and I can only say that he is equally energetic in this Company. He seems to have everything at his fingers' ends, and is almost every day at the office. Though he may have a great deal of work to do, he is an extremely energetic and capable man. I may just add that we telegraphed to hear the state of Mr. Field's health, and we have just received this reply:—"2:50 p.m. Field's condition practically unchanged. He is in a very weak state, but all his friends hope for the best." I am sure that that includes all his friends on this side. The speaker then put the resolution to the meeting, and it was carried *nem. con.*

On the motion of Sir JAMES ANDERSON, seconded by Sir ALBERT J. L CAPPEL, Mr. Bevan was re-elected to his seat at the Board, as was also Mr. Charles Burt, on the motion of the Chairman, seconded by Mr. Weaver.

Mr. NEWTON afterwards proposed the re-election of the auditors, Messrs. John Gane and Joshua Dean. He expressed his belief that a good deal of time would be saved at their meetings if some scheme could be carried out for conciliating the interests of the Preferred and Deferred shareholders.

Mr. JOHN BROWN seconded the motion, which was adopted.

The proceedings then terminated in the usual manner.

City and South London Railway Company (Limited).

The ordinary half-yearly meeting of this Company was held on Tuesday last at Winchester House, Old Broad-street, under the presidency of Mr. C. G. Mott.

The SECRETARY (Mr. W. F. Knight) read the notice convening the meeting. The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN, after expressing on behalf of the Board their deepest sympathy with the Royal Family in their great bereavement, by the death of the Duke of Clarence and Avondale, who was present at the opening of the City and South London Railway little more than a year ago, and who had always evinced a great interest in the line, said he regretted that they had to meet again without being in a position to declare a dividend on the ordinary stock. During the first half of the present year they had, in common with many other lines, an unsatisfactory traffic, which on their line was especially affected during the holiday season by the absence of many of their regular travellers. They anticipated that this would have been more than made up by the increase of traffic that they would receive from the almost daily cricket matches at the Oval. Unfortunately, the weather was extremely bad during the whole of that period; and there was hardly a cricket match that was in any way a success, and they got little or no additional traffic from that source. The result was that their average receipts for the first quarter of the year were only £711 a week. After the holiday season was over and people began to get more confidence in their line, their traffic began steadily to increase—so much so that in the second quarter of the year their average receipts were raised to £802 a week. They thought that the want of the increase in the first part of the year might be due to their fares being considered excessive at some periods of the day, and that a reduction of those fares might result in an increased income. They did reduce and vary the fares, and on the whole they felt that so far that reduction had been successful; but in some cases they had since found that they could increase the fares again without losing any of their traffic, and they were taking every opportunity of carrying out that policy. The average fare per passenger in the first half of last year was 1.9d.; in the second half of the year it was reduced to 1.7d., exclusive of the season ticket holders. The difference in the decimal amounted to more than £2,000; but this had been more than made up by the increased number of passengers that they had carried; and, therefore, on the whole half year they showed an increase in total receipts of some £600. When they began to raise the fares, as they did on November 1st last, they introduced a system of season tickets, which had been largely taken advantage of. The number of season tickets was steadily increasing, and he was glad to say that those which had just expired were being nearly all renewed, showing that the season tickets had met the demand, and that the Company were giving satisfaction to the holders. The great fault of the line was the want of sufficient traffic and sufficient receipts. Their receipts per train mile were 2s. 1¼d. Now, the average receipts for the steam railways of England were about 5s. per train mile; in fact, in passenger lines they exceeded that usually. Their expenses per train mile had only been 1s. 7¾d.; those of an ordinary steam railway were 2s. 9d., so that the Company's expenses were very much lower than

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those of a steam railway. But, of course, their trains did not carry so large a number of passengers as those on an ordinary steam railway. He would deal with this point presently. Their total expenses appeared to be very high. They were always high at the early stages of a new railway. They amounted to 76 per cent. of the receipts for the half-year; but when they compared these figures with those of an ordinary railway, they must recollect that in addition to the usual traffic of steam railways they had to work the lifts which took the passengers up and down—a matter quite extraneous to an ordinary railway—and if they deducted the cost of working those lifts, it would be found that the expenses of the past half-year were reduced to 66½ per cent. of the earnings. If their receipts had also increased, and, instead of being a little over £20,000, had been as much as £30,000, they could have carried that traffic at practically little or no increase of expenditure, their working expenses would have been reduced from 66½ to 45 per cent.—a figure lower than was reached by any steam railway in the kingdom. In the early stages of a railway the percentage of expenses was always higher than it was after the traffic developed. In the case of the London, Brighton and South Coast Company, for instance, their expenses in 1867 were 85 per cent. of their receipts; whereas their expenditure last half-year was 48¾ of their earnings, so that the growth of traffic brought down the percentage very rapidly and very largely. The expenses of the London, Chatham, and Dover Railway Company, about the same time, were 71 per cent. of their earnings. Therefore, so far as their position in point of age was concerned, they were very much in advance of those two Companies. They were only a year old, and those Companies at the time he referred to had been in existence some years. Their expenses this half-year had shown certain decreases which had been, unfortunately, counterbalanced by certain increases on the other side of the account. Some of these were referred to in the report. They had had an increase in the item of compensation. They had had one or two claims brought against them which they thought it was better to settle, although he did not think they were just. The rates and taxes had increased in the half-year to the extent of £152. On the other hand, locomotive expenses had decreased by £388; traffic expenses had decreased by £38; maintenance of the line had increased by £104, and there was a small rise in the general charges. The result was that the expenses as compared with those of the previous half-year, showed a trifling decrease. It would be very interesting, he was sure, after their year's experience, to give them some facts and comparisons in respect of their working, which they were not able to give before. They could not, of course, say for a moment that the present condition of their working was by any means perfect; but they were improving it every day, and they hoped they were going to lessen its cost. He would, however, give them a few of the results which they had learned so far. Let them look first at the locomotive expenses, which formed a question of electricity *versus* steam. Their locomotive expenses were 7·88d. per train mile. Now, the locomotive expenses of the main lines of the country, such as the London and North-Western, the Great Western, Midland, and Great Northern, were something like 9d. per train mile last half-year. But this was not all. Their charge of 7·88d. included the high price paid for coal, its carriage, and cartage to their depôt. In the case of the companies he had cited, the price they paid was that charged at the pit's mouth, and no carriage was paid at all. If they would deduct from their expenses the amount which they would have saved in their coal if they had been in the position of those other companies, it would be found that the cost per train per train mile was reduced to 6·6d. against their 9d. In the case of companies which paid carriage on their coal, such as the London, Brighton, and South Coast, the cost was 10d. per train mile. It would be interesting to consider in this connection what were the advantages they claimed from electricity. They had told them in the report that "after the experience of the past year, there is every reason to be satisfied with the use of electricity as a motive power for the working of this railway, and for a confident belief that when all the details are fully perfected, it will be found to be at once safe, convenient, and economical." Its safety they had proved, because they had had no accidents; its convenience had been proved, and would be far more so in the future than in the past. He would come now to the question of its economy. He had told them that their expenses were 1s. 7¾d. against the usual price on steam railways of 2s. 9d. per train mile. The reply to this was, of course, "Your trains are very much smaller and lighter." That was perfectly true; but they must recollect this, that the average number of people they took in a train last half-year was 47; and they were capable of taking three times that number. The ordinary steam trains all over the country took an average of 45 passengers per train mile, and the rest they carried was dead-weight not paid for. The Board held that instead of running huge trains only partially filled, it was better to run small and lighter trains which held a greater number of passengers proportionately to their weight, and that they had better increase the number of light trains than have few of heavier weight. This was more for the public convenience, and would in the end be found more economical. In an ordinary steam railway it was reckoned generally that a ton weight of carriages would provide seats for three persons. Of course he was not speaking of Pullman trains, but the ordinary ones. For every one ton of weight they might take it that three persons were accommodated. Now, in their trains for every ton of weight they had five persons accommodated. Therefore, in their electrical arrangement they had a decided advantage over a steam railway. He was very much surprised in reading the report of the Metropolitan Railway Company's meeting the other day, to see that that very able and experienced Chairman, Sir Edward Watkin, whom they looked upon as a special expert in railway matters, gave it as his opinion, which was always valuable, before the Metropolitan shareholders that an electric engine could only draw a train equal to its own weight. Let them see how far this was correct. Now, an ordinary steam passenger locomotive, such as was run on our main lines, was reckoned to take three times its own weight behind it; this was to say, that if they took an engine of 80 tons weight it would draw 240 tons behind it. Now, their electric engines at the present time always took three times, and often four times their own weight. They must also recollect that in running over their line they were not simply taking three or four times the engines weight, but taking it up an incline the gradient of which was 1 in 27, and which had a reverse curve of a little over three chains in radius. He did not think that Sir Edward Watkin had an engine on his line that could do that. Therefore, they were clearly surpassing by electricity steam power, having regard to the work done. These were very important facts to have learned. Now, as to their speed. Their average speed of working at the present moment was 13 miles an hour, including stoppages. They reckoned that they would be able by-and-by to work faster; but they must recollect that that was considerably above the average speed which the Metropolitan trains attain in the inner circle, in which they did not run at 13 miles including stoppages. These figures showed clearly that although electricity was only in its infancy—this being the first line of its kind, and only a year in operation, and therefore affording them no real opportunity of testing it—they would see that electric power was not a matter which engineers of to-day could afford to despise. He confessed, having had a long experience, as they knew, of the management of steam railways in this country and elsewhere, that he could not help feeling that the facts they had learned in the past year pointed at no very distant date to the substitution of electricity very largely for steam on the railways of the world. It was always well when they got to a certain point to look back and see what their expectations were when they started an undertaking. If they looked back to their original prospects—he referred to the time when they contemplated running only to the Elephant and Castle — they estimated that there would be a very large traffic. They believed that at the time, and if they followed the advice of the Board and allowed them to carry out the plans they had in view now, he believed that the tims was not very distant when those traffic expectations would be realised, large as they were. If they looked also at the expenses, it would be found that their first estimate of expenses was based on what was supposed to be at the time the most economical mode of working, an endless cable system—they would find that their first estimate rather exceeded the amount at which they were now working. He always considered, after he had gone into it very carefully, that it was very doubtful whether that estimate was not too low. In the second prospectus which they issued they raised it considerably. He did not think it would be possible to work this line with a cable system. The cable system was an excellent one for certain purposes—for steep hills, for example—because there they got the full advantages of gravitation But to work such a railway as theirs by a cable would involve an enormous strain on the cable, which, moreover, would require to be very strong and so heavy that its weight would be probably twice, if not more, the weight of all their locomotives put together. Then the difficulty of working round a curve and the friction involved in working over pulleys on a line of this kind, would be very great. It seemed to him that the expense would be very great If they had a very large weight to move and had all that friction, he did not think they could have such an economical arrangement as they had in electric engines, in connection with which the friction was very small, and which did a large amount of work with a small expenditure of power. He thought, therefore, they would see that they were justified in what they said in the report that the future of electricity was very promising indeed. Most of their line—nine-tenths—was a good line, and well constructed. He was sorry to say that one-tenth, unfortunately, had been an engineering difficulty. He referred to the part at King William-street Station, and the inclines leading to it. The station was too short, the inclines were too steep, and the curves as they came towards it were very heavy indeed. They wanted, if they could, to add another carriage to each train, but they could not do so because of King William-street Station. The inclines leading to it, which involved them in additional expense for additional power, would be quite unnecessary if they could get rid of it. They could work the line cheaper. The station could not be enlarged. It was so placed that they had the Monument in front of them, and they would not be allowed to approach nearer to that structure. The consequence was that they could not widen the station except at great risk and expense. Now they had been considering if they could not in some way get rid of the station and the inclines altogether. It was a very small portion of the line. Fortunately it was not a very expensive portion, and it would be always extremely useful, even if they substituted for it another line. In order to place the line in such a position that they could work it economically and meet the growing traffic, they thought that there were no other means of doing so than by having a through station in the City instead of a terminal one as now. Unfortunately, all the steam railways came into the City with the exception of the Metropolitan and Inner Circle had all terminal stations, and much they regretted that it was so. All the stations which dealt with the City traffic at those termini were every one of them taxed to their utmost with the constantly increasing traffic. It was a problem which it would in the future take the wisest heads to solve. It took them four or five times the time to deal with trains at a terminus than it would at a through station. They knew what a large expenditure the Great Eastern were going to now in widening the Liverpool-street Station; and even when that was done it would only be a few years before they would be in a similar difficulty to that which they were in now. With all this knowledge before them they felt that, before they went to the expense of making an expensive terminal station, it was wiser at once to take advantage of the experience of the past, which had been gained at a vast expenditure of capital on the part of other railways, and get a through line in the City, and that they should make their terminal station where they could get land at a small cost, and have a number of sidings. It took two or three minutes to get a train in and out of King William-street Station. They would see, therefore, the enormous advantage there would be if they could deal with the growing traffic, and the excessive traffic morning

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and evening, and at a less cost per train mile. They had at present powers far in excess of their immediate wants. They could work a much longer line than they were able to do now. All this pointed to the wisdom and desirability of the plans that they had now deposited in Parliament. They had looked about them to see in what way they could make those plans work as economically as possible. They had arranged with the London, Brighton, and South Coast Company for a station at the bottom of Denman-street; and it would be able to throw upon them an enormous traffic from that Company's station. The promises of that line for traffic were exceedingly good in every way. They felt that, under their present condition, until they were in a better financial position, they might have some difficulty in raising the capital upon proper terms. They had, therefore, taken power to convert such portion of it as might be necessary to an independent Company, so as not to throw the burden on this Company; but this would enable them to make certain arrangements by which this Company would have all the benefit, and he thought he saw their way to find the necessary capital to work it out. The question as to whether it was to be a separate capital could be determined after they got the Bill. He would gladly have postponed their application to Parliament if he could. They had considered every possible means of obviating their difficulty, and it was only under the strongest feeling that they came to the shareholders and said that in the interests of the Company they could not postpone their application to Parliament for a year. They had come to the absolute conclusion that it was essential to the success of the Company that the Bill should go on, and the Directors asked for the thorough confidence of the shareholders in appealing to them to approve of the Bill. If they thought that the Bill was not in the interests of the Company, then, as far as he was concerned, he was bound to their decision, but he might say that he was not prepared to carry on the business of the Company if that were so. He was so thoroughly convinced that the future of the line was perfectly assured if the Bill went on, and was risked in a most serious manner, if it did not, that he was prepared to base his position entirely on the question. He concluded by moving the adoption of the report and accounts.

Mr. S. HANBURY seconded the motion.

Mr. DRAKE thought that their small enterprise should not be compared with other enormous railway undertakings. Their profits were creeping up, and he hoped that with a little more economical management they would eventually attain a fair remuneration for the money expended.

Mr. MIDDLETON said that he had taken great interest in the working of the line, and he was very pleased to corroborate the Chairman's figures that the price per train mile had gone down very considerably since the previous half-year. He believed that they had reduced the working expenditure from £17,000, to about £15,000. He only wished to impress upon the Board that there was still scope for a considerable reduction in the item, and he trusted that their energies would be rather devoted to that than to any scheme of extension.

Mr. VAN LAREN said that they had been told that electrical traction was a success and perfectly safe; but how was it that their shares stood at the figure they now did?

The CHAIRMAN said he could assure the shareholders that, so far from considering electricity a failure, he considered, from what was known of it, that it was a most decided success in point of locomotion, and promised to be in every way a most satisfactory mode of working this line of railway. They could not be supposed to get a dividend until they equipped the line. They had only been at work one year. During that time they had not only paid their debenture interest, but they had carried forward an amount which might have been distributed as a small dividend; but they did not think it desirable to do so, because if they went on as they proposed, when next they met it would be to declare a dividend on the ordinary stock. He confessed that he did not see any reason to suppose that they would not be in a position to do so provided everything went on as they had arranged. Their opinion in every way was that electricity was a satisfactory power. As to the various stoppages of the line which had taken place he must remind them that they were under the glare of the light of public opinion as a new undertaking as to which every possible fault was found. There was no doubt that they had stoppages occasionally—generally from five to ten minutes—and unfortunately they always occurred during the busy times, and arose from the strain which was put upon the motors, and the engines in going up the incline that led to King William-street. It was found that the mode of winding the armatures of the motors was not perfectly satisfactory, and it was there that short circuits took place. That would be remedied at once if they had had a larger surplus stock of engines. They were re-winding those armatures on an improved plan, and they had experienced no breakdown from these. There were a great many of them in use, and they could only re-wind them by degrees. If the passengers were delayed 10 or 20 minutes they wrote to the newspapers and made a disturbance about it; whereas if there was any delay on other railways there was no notice taken of it. He quite agreed with Mr. Middleton that it was desirable to keep down the expenses whenever it could be done. From his own experience and knowledge he thought they would be extremely foolish if the shareholders did not authorise them to carry out the policy which they had most carefully considered.

The resolution was carried.

The CHAIRMAN, who was unanimously re-elected to his seat at the Board, in expressing his thanks for the compliment, said that he had had a great deal of anxiety and work in connection with the line; but he was thankful to say that he now saw daylight through it, and that there was a future for it which would place it in a far better position than any line in the country.

A special meeting was afterwards held to gain the approval of the shareholders of the Company's Bill now pending in Parliament.

The SOLICITOR to the Company explained the various clauses of the Bill requiring elucidation.

The CHAIRMAN then said that the Company had power under their Acts to make a station at the end of Denman-street; and the Brighton Company had agreed that their Company should construct a subway through their station on to that Company's platform, where their principal suburban trains start and arrive. They also proposed to construct two tunnels under the river, with easy inclines, to a central station at the corner of Lombard-street, and thence by way of Moorgate-street to the Angel at Islington, where they would get ample siding room. He concluded by moving the adoption of the Bill.

Mr. HANBURY seconded the motion.

Mr. MIDDLETON moved, and A SHAREHOLDER seconded its rejection.

The CHAIRMAN put the resolution, and declared it carried by twenty-six to five votes.

Mr. MIDDLETON thereupon demanded a poll.

The CHAIRMAN fixed the poll for Tuesday next, from 12 to 2 p.m., at the offices of the Company, King William-street.

A vote of thanks to the Chairman terminated the proceedings.

Central London Railway Company (Limited).

The first ordinary general meeting of the Central London Railway Company was held at the offices of the Company, No. 30, St. Swithin's-lane, E.C., on Wednesday, February 3rd, for the transaction of the general business of the said Company; Mr. F. A. Lucas presided.

Mr. T. MATESDORF (the Secretary, *pro tem.*) read the notice calling the meeting.

The CHAIRMAN said: Gentlemen, I am not going to make a speech, as this is merely a formal meeting, summoned in accordance with the Act of Parliament; and as no shares have been issued, it is practically a meeting of contributors; and so I will proceed at once to the first object of the meeting which I shall have to move. Messrs. E. G. de Crano, F. A. Lucas, H. Mosenthal, and D. Parrish, the first Directors of the Company named in section 31 of the Central London Railway Act, October, 1891, retire from office, under the provisions of such section; but, being qualified, offer themselves for re-election as Directors. I have, therefore, to move

"*That Messrs. E. G. De Crano, F. A. Lucas, H. Mosenthal and D. Parrish be and they are hereby re-elected Directors of the Company.*"

Mr. H. OPPENHEIM seconded the motion.

The resolution was carried without discussion.

The CHAIRMAN stated that that concluded the business of the statutory meeting, and he called upon the Secretary to read the notice of the Wharncliffe meeting.

The SECRETARY then read the notice, which stated that the object of the meeting was "for the purpose of submitting to the proprietors at such meeting a proposed Bill in Parliament to be entitled 'A Bill to confer further powers on the Central London Railway Company, and for other purposes'"

The CHAIRMAN then called upon the Solicitor of the Company to shortly explain the objects of the Bill.

Mr. MORRIS said that, briefly, the position was that by the Act of 1891, the Central London Railway Company was incorporated, with authority to make a railway six miles in length from Shepherd's Bush to Cornhill, in the City of London. By the Bill before the meeting, they proposed to abandon so much of the authorised line as went into Cornhill, and instead to make a through railway, by way of Threadneedle-street and Broad-street, to the Liverpool-street Station of the Great Eastern Railway Company, doing away with the projected central station in Cornhill. It was proposed to connect the Central London Railway at Liverpool-street with the Great Eastern Railway and the North London Railway by means of a subway; that, briefly, was the object of the Bill.

The CHAIRMAN: I beg to move:

"*That the Central London Railway Bill, 1892, as proposed to be introduced into Parliament, be, and the same is, hereby approved, subject to such addition alterations, and variations as Parliament may think fit to make therein.*"

Mr. H. MOSENTHAL seconded the motion, which was at once carried without discussion; and a vote of thanks to the Chairman closed the meeting.

Cuba Submarine Telegraph Company (Limited).

The following is the report of the Directors of this Company for the half-year ending December 31st last, to be presented at the forty-first ordinary general meeting of shareholders, to be held at the offices of the Company, 58, Old Broad-street, E.C., on Wednesday, the 10th inst., at 12 o'clock:—

From the accounts it will be seen that the gross receipts (including the balance brought from last account) amount to £21,677. 2s. 4d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable) to £6,710. 16s. 0d., leaving a sum of £14.966. 6s. 4d. to the credit of revenue account. Of this the sum of £5,000 has been added to the reserve fund, which now stands at £83,000.

The dividend on the Preference shares will absorb £3,000, and leave £6,966. 6s. 4d., out of which the Directors recommend the payment of a

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dividend on the Ordinary shares at the rate of 8 per cent. per annum, free of income tax, the balance, £566. 6s. 4d., being carried forward to the current half-year's account.

The cables have continued in good working order throughout the half-year. The Company's suit against the Spanish Government at Madrid is progressing.

Annexed to the report is a comparative statement of the Company's traffic for the last two years.

NEW COMPANIES, STATUTORY RETURNS, &c.

ELMORE'S AMERICAN AND CANADIAN PATENT COPPER DEPOSITING COMPANY (LIMITED).—This Company was registered on January 26, 1892, with a capital of £200,000, divided into 65,000 priority shares and 35,000 deferred shares of £2 each, by Harry Ellis, 64, Cannon-street, London, E.C. The objects are to enter into and carry into effect an agreement which has already been prepared and is expressed to be made between Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited) of the first part, Woodhouse and Rawson United (Limited) of the second part, and this Company of the third part, and is to be signed immediately after the incorporation of the Company; to carry on in the United States of America, Canada, and elsewhere, the business of manufacturers of and dealers in copper and other metals, and all metallic alloys or compounds of the same, and all articles made of copper and other metals and alloys; "to carry on the business of supplying electricity in all its branches, and to construct, lay down, establish, fix and carry out all necessary cables, wires, lines, accumulators, lamps and works, and to generate, accumulate, distribute and supply electricity, and to light buildings and places, both public and private, wherever situate; and to carry on the business of electricians, electrical contractors, electrical and mechanical engineers and suppliers of electricity for the purposes of light, heat, sound, power or otherwise, and of manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, distribution, supply, accumulation and employment of electricity." The subscribers are:—

	Shares.
James Shurmer, 22, Ossory-road, S.E.	100
R. J. Cox, 31, Railton-road, Herne Hill, S.E.	1
D. R. Allen, 2, Gordon-terrace, Sydenham, S.E.	1
John J. Atkinson, Cosgrove Priory, North Hants	500
William Elmore, Worcester House, Walbrook, E.C., electro-metallurgist	500
John A. Ewen, 11, Bunhill-row, E.C., merchant	500
Frederick L. Rawson, 3, Kensington Court, W., electrical engineer	500

The number of Directors, exclusive of local and Managing Directors, shall not be less than three nor more than nine. The first Directors of the Company shall be elected by the subscribers to the memorandum of association, or a majority thereof, by writing under their hands. Qualification: shares or stock of any denomination in the Company of the nominal amount of not less than £500. The remuneration of the Directors shall be £200 per annum each, with an additional £200 per annum for the Chairman and £100 for the Vice-Chairman, together with 10 per cent. commission upon the net profits in any year remaining after payment of a dividend of 30 per cent. upon the priority shares of the Company; and such remuneration shall be divided between them in such proportion as the Directors may determine.

BENRY TOOLEY AND CO. (LIMITED).—This Company was registered on January 30, 1892, with a capital of £10,000, in £5 shares, by A. P. Honeyman, 9, Bennett's-hill, Birmingham. The objects are to acquire and carry on the business of military weapon manufacturers, mechanical and electrical engineers, founders, machinists, &c., carried on by Henry Tooley and Co., at the "Times Works," 65 and 66, Weaman-street, Birmingham, and 59, Rue Meslay, Paris. Registered without Articles of Association.

TWEDDELL'S SYSTEM (LIMITED).—A Company has just been registered, with the above title, to purchase and take over as a going concern the business of Ralph H. Tweddell, of 14, Delahay-street, Westminster, London, S.W., engineer, and to carry on the business (amongst others) of consulting engineers, ironfounders, mechanical engineers, electrical engineers, &c. It has a capital of £10,000, divided into 200 Six per Cent. Preference and 800 ordinary shares of £10 each, and was registered on January 25, 1892, by Waterlow Brothers and Layton (Limited), 24 and 25, Birchin-lane, London, E.C.

BRITISH TANNING COMPANY (LIMITED) (TANNING BY ELECTRICITY).—The annual return of the above-named Company, made up to January 1, 1892, was filed on the following day. The Company was registered on April 10, 1889, with a nominal capital of £70,000, in £1 shares, to purchase, or otherwise acquire, certain letters patent for the United Kingdom of Great Britain and Ireland, granted to E. Worms and J. Balé, No. 9,515, on July 5, 1887, for an invention for an improved process and apparatus for tanning by the aid of electricity, and to develop and turn to account the same. At the time of making up, 35,140 shares had been taken up, the full amount called upon each, resulting in the payment of £33,732. 10s., leaving £1,407. 10s. in arrears. Registered office: 17, Basinghall-street, London, E.C.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—The annual return of the above-named Company, made up to January 5, 1892, was filed on January 12th following. The Company was registered on May 29 1889, with a nominal capital of £500,000, divided into 49,900 ordinary and 100 founders' shares of £10 each, to acquire and carry on certain businesses, particulars of which were not given, and to construct, establish, and carry on any works, machinery and apparatus for lighting streets and other places, public and private, by electricity. At the time of making up all the shares had been taken up, and upon 45,100 shares the full amount had been called, resulting in the payment of £442,790, and leaving £8,210 in arrears. The remaining 4,900 were issued and considered as fully paid. Registered office: Worcester House, Walbrook, London, E.C.

FOWLER-WARING CABLES COMPANY (LIMITED).—The annual return of this Company, made up to January 1, 1892, was filed on January 6th following. The Company was registered on August 13, 1889, with a nominal capital of £200,000, divided into 39,700 ordinary shares of £5 each, and 300 founders' shares of £5 each. At the time of making up 20,000 ordinary and 300 founders' shares had been taken up, the founders' having been issued and considered as fully paid. Upon the ordinary shares £4. 10s. per share has been called, resulting in the payment of £89,850, and leaving £150 in arrears. Registered office: Victoria Mansions, 32, Victoria-street, Westminster, London, S.W.

PHONOPORE SYNDICATE (LIMITED).—The annual return of the above-named Company, made up to January 5, 1892, was filed on January 12th following. The Company was registered on December 10, 1887, with a nominal capital of £90,000, divided into 60,000 ordinary and 30,000 deferred shares of £1 each, to acquire certain letters patent and inventions, trade marks, &c., and to establish and carry on the trades and businesses of manufacturers of electrical batteries and other apparatus. By a special resolution passed December 22nd, 1890, and confirmed January 15, 1891, the capital was raised to £100,000 by the addition of 10,000 ordinary shares of £1 each. At the time of making up 90,000 shares had been taken up, of which 39,025 ordinary, and 30,000 deferred shares, had been issued as fully paid. The remaining 20,975 ordinary shares have had the full amount called, and all calls paid, amounting to £20,975. £676 has been paid on 676 shares forfeited. Registered office, Blomfield House, London Wall, E.C.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended January 31st amounted to £823, as against £703 for the corresponding period of 1891, an increase of £120. The total receipts to date, from January 1, 1892, are £3,650, against £3,330, in the corresponding period of 1891, an increase of £320.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of January were £3,500, as compared with £2,439 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of January, 1892, were £2,195, against £2,147, showing an increase of £48, as compared with the corresponding period of 1890.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of January amounted to £63,436, and to £60,005 in the corresponding period of last year, an increase of £3,341.

EASTERN EXTENSION TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the month of January, 1892, amounted to £42,805, against £46,575 in the corresponding period of 1891.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—At a Board meeting on Tuesday it was resolved:—"That a payment on account of the dividend of the current year be made: On the 89,261 shares, £3 paid, of 5s. 3d. per share; on the 5,000 fully paid shares, allotted to the Edison Company, 8s. 9d. per share; on the 12,139 fully-paid shares, allotted to the Swan United Company, 7s. 8d. per share." The dividend warrants will be issued on the 22nd inst.

ELMORE'S AMERICAN AND CANADIAN PATENT COPPER DEPOSIT COMPANY (LIMITED).—During this week another Elmore Company has been floated, or rather has been placed upon the market, and notwithstanding the fact that previous Elmore issues have not realised the sanguine results anticipated by the promoters. The Directors of the present Company opened their lists on Monday last, and closed them the same day at four o'clock. The American and Canadian Elmore Company has been registered, with a capital of £200,000 in 65,000 priority shares and 35,000 deferred shares, both of £2 each. The Chairman of the Company is Sir Francis de Winton, and the Messrs. F. E. Elmore and A. S. Elmore are the consulting metallurgical chemists. The offices are at 64, Cannon-street, and the secretary is Mr. J. Shurmer. The objects of the Company are similar to those of the Foreign and Colonial Elmore Company, and the prospectus is chiefly noticeable for the details given of the dividends which are expected to come from the sale of the patents to subsidiary companies. It is not the intention of this Company to work the process itself (the prospectus states), further than the erection in New York of a plant of sufficient size to demonstrate on a working scale the merits of the invention. The other points of the prospectus are similar to those of previous Elmore issues, with which our readers must by this time be familiar. The press have been informed that letters of allotment were posted on Tuesday evening. The applications are said to have been very numerous.

NORTH METROPOLITAN TRAMWAYS COMPANY (LIMITED).—At the half-yearly meeting, held on Wednesday, Mr. G. Richardson, the chairman, said that the arrangements entered into with the General Electric

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Power and Traction Company (Limited) for working the Barking-road section by electricity were still in operation, and during the last half-year 38,631 miles had been run.

VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY (LIMITED).—Coupon No. 3 of the Five per Cent. Mortgage Debentures of this Company, due January 31st, will be paid, free of income-tax, upon presentation to the Consolidated Bank (Limited), Threadneedle-street, London, E.C., or at the banking house of Messrs. Westendorp and Co., Amsterdam.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the half-month ended January 31, 1892, were £2,735, as compared with £3,791 for the corresponding period of last year.

THE LIVERPOOL ELECTRIC ASSOCIATION FOOTBALL CLUB.—The above club held their second annual dinner at the "Eagle" Restaurant, Castle-street, Liverpool, on Saturday last. The dinner was preceded in the afternoon by a football match between the married and single members of the club, which the former won by four goals to one. In the evening the party, numbering about 80, included Mr. A. Bromley Holmes, Managing Engineer of the Liverpool Electric Supply Company (Limited), Mr. B. H. Collins, Secretary, Mr. A. Clough, Works Manager, and Mr. Naftel, Chief Electrician. The dinner was followed by a miscellaneous entertainment.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Jan. 27.	Price Wednesday, Feb. 3.	Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending Feb. 3. Highest.	Lowest.
			TELEGRAPHS.						
£1,300,980	Stock	12/6	Anglo-American	51 52	50 51	5 2 8	Jan., Apr., July, Oct.	51⅞	51
£2,849,510	Stock	25/0	Do. Preferred	89½ 90½	89 90	5 16 4	,, ,,	90½	89
£2,849,510	Stock	5/0	Do. Deferred	13 13½	12½ 13	.. ..	,, ,,	13 1/16	12¾
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10¼ 10¾	10½ 11	7 5 6	Mar., June, Oct., Dec	10⅝	10½
£68,200	£100	5%	Do. 5 per Cent. Bonds xd	102 105	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 5	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	153 157	153 157	4 9 2	April and October ..	..	..
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	10 1/16	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	,, ,,	..	..
12,981	5	2/0	Direct Spanish (£4 paid)	3¼ 3⅝	3¼ 3⅝	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	8¼ 9½	5 5 3	,, ,,	..	..
60,710	20	3/6	Direct United States	11 11¼	11 11¼	6 5 0	Jan., Apr., July, Oct.	11⅛	1 1 3/16
400,000	10	2/6	Eastern	14⅜ 14⅝	14⅜ 14⅝	3 16 0	,, ,,	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	,, ,,	15½	15 3/16
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106 109	107 110	3 12 9	May and November	109	108
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899 xd	108 111	105 108	4 12 7	February & August	106	..
250,000	10	2/6	Eastern Extension	15⅛ 15⅜	15 15½	4 11 10	Jan., Apr., July, Oct.	15 5/16	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock xd	107 110	105 108	3 14 1	February & August	109	107
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July ..	103½	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb. 1900	101 104	101 104	4 16 2	,, ,,	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.) xd	99 102	98 101	3 19 3	Febuary and August	101½	..
180,227	10	1,6	Globe Telegraph and Trust xd	9⅞ 10⅛	9⅞ 10⅛	5 6 2	Jan., Apr., July, Oct.	10⅛	9 13/16
180,042	10	6%	Do. 6 per Cent. Preference xd	14¾ 15⅛	14¾ 15	4 0 0	,, ,,	15 1/16	14 13/16
150,000	10	5/0	Great Northern	19 19½	19 19½	4 7 2	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	106 109	4 11 9	March & September	..	..
17,000	25	12/6	Indo-European	41 43	41 43	5 16 3	May and November	42¼	41
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 8 7	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	7⅛ 8	7⅛ 8	5 3 2	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	116 121	116 121	4 18 4	,, ,,	..	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	101 104	101 104	4 6 7	March & September	..	..
30,000	10	2/0	West Coast of America	4 5	4 5	.. ..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	99 103	101 105	7 12 5	June and December	104½	..
88,321	10	1/0	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	.. ..	,, ,,	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 9¾	9½ 10	6 0 0	May and November	9 13/16	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8½ 9½	6 6 4	,, ,,	9	..
67,007	15	6/0	Western and Brazilian	10 10½	10 10½	7 2 10	,, ,,	10½	10⅜
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6¼ 6⅝	6¼ 6⅝	5 7 3	,, ,,	6¼	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	3¼ 4¼	3¼ 4¼	.. ..	,, ,,	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910 xd	104 107	101 104	5 15 5	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910 xd	104 107	101 104	5 15 5	,, ,,	..	..
$1,386,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,860	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜ ½	⅜ ½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	7/16 ⅝	7/16 ⅝	6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅛ 4⅜	4⅛ 4⅜	6 17 2	June and December	4¼	4 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13	12⅝ 13⅛	4 12 4	,, ,,	13⅛	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12 12½	11⅞ 12⅜	4 16 0	,, ,,	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	105 107	104 107	4 4 1	January and July ..	106	105½
58,000	5	1/0	United River Plate	1 2	1 2	.. ..	,, ,,	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	80 90	80 90	5 11 1	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£6 paid)	6 6½	6 6½	..	..	6½	6⅛
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	.. ..	.. ..	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	..	5½ 6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	5½ 6	..	January and July ..	..	..
90,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2⅜ 2⅞	2⅜ 2⅞	..	March	..	..
10,000	£5	3½%	Do. (fully paid)	4¾ 5	4¾ 5	..	March	..	..
111,000	5	..	London Electric Supply	1⅜ 1⅝	.. ..	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9 9½	9 9½	..	..	9 1/16	8½
6,318	10	..	Notting Hill Electric Lighting (fully paid)	5½ 6½	5½ 6½	..	..	..	..
13,680	£5	10%	St. James' and Pall Mall xd	8½ 9	8½ 9	..	..	9	8 15/16
7,900	£5	7%	Do. 7% Preference xd	7 7½	7 1/16 7⅜	..	..	7 5/16	7⅛
42,853	5	..	Westminster Electric Supply (fully paid)	6¾ 7¼	6¾ 7¼	..	..	7	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1 8	Brush Electrical Engineering xd	3½ 3⅝	3½ 3⅝	..	..	3 7/16	3½
69,996	2	6%	Do. 6 per Cent. Preference xd	2⅛ 2⅜	2 2¼	5 7 7	..	2¼	2
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 6	5⅝ 6	5 16 8	January and July ..	5⅝	..
17,130	5	17½	Edison and Swan United	.. ..	.. ..	..	..	..	..
45,000	10	12/0	Electric Construction	6 6½	6 6½	..	..	6 1/16	6
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅜ 3⅝	3½ 3⅝	..	..	3 1/16	2 15/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	21½ 22	22 23	4 6 11	February & August	23	21⅝
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½ 4½	3½ 4½	.. ..	..	..	..
11,334	£10	8/0	Do. Preference	8 9	8 9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛ ⅜	⅛ ⅜	.. ..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	3½ 4	3½ 4	9 13 0	May and November	3 15/16	3⅜
36,250	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July.....	43⅛	43½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100 103	100 103	4 17 1	January and July ..	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	1⅜ 1⅝	.. ..	5 15 9	..	..	..
..	£5	8%	Do. Preference (fully paid)	3½ 3¾	.. ..	10 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	..	..	..	..
50,000	£10	..	City and South London Railway	2½ 3½	2½ 3½	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

The Corporation of Bradford certainly deserves congratulations on the satisfactory progress which is being made in the electric supply which they have undertaken; and there seems to be every probability that another half-year will wipe off the losses of past years, which were inevitable in the beginning of such an undertaking. The average price of coal being 7s. 7d. a ton delivered at the works, no doubt tells favourably on the expenses; but the two-wire system, which is still employed, must somewhat handicap the concern, especially as regards the capital account. We are unable to go closely into the figures, as invited by the Chairman of the Committee, since the details have not yet reached us. The ·58d. for coal per unit represents about 14½ lbs. per unit, which is rather more than double the quantity used at the best London stations. Of course, an engineer would not be so careful with coal at this price as with the best Welsh that has to be used in London. We do not, however, attach great importance to this item, and would rather see some of the items relating to cost of management and distribution.

Some months ago we called attention to the fact that Mr. C. P. Steinmetz had discovered a very simple empirical formula, expressing the loss of energy in iron cores due to hysteresis. The numerical results obtained by Prof. Ewing for different magnetisations showed, on examination, that the loss of energy during a magnetic cycle was proportional to the 1·6th power of the maximum density of magnetic lines during that cycle. Mr. Steinmetz has recently made an exhaustive analysis of the phenomenon of hysteresis, with the view of putting this useful working formula to a thorough test. His Paper, an abstract of which we publish this week, is of considerable interest on account of the importance of the phenomenon itself, and because the only thorough investigation of it yet made was carried out by Prof. Ewing more than seven years ago, when the practical bearing of the phenomenon was but little appreciated. There is, however, one characteristic of the present experiments which makes them especially valuable; many of them have been carried out with alternate currents, the iron losses being directly measured with alternate-current instruments, instead of by static methods, such as Prof. Ewing used. The agreement between Mr. Steinmetz's results and those of Prof. Ewing is as satisfactory as could have been reasonably expected, and may be said to form the first proof that the static method yields results applicable to alternate-current work. A difficulty arises in interpreting the results of the present experiments, owing to the need of separating the losses caused by eddy currents from those due to hysteresis proper; but this difficulty appears to have been surmounted, and the result is to show that Mr. Steinmetz's law—that the loss of energy in a magnetic cycle is proportional to $B^{1.6}$, where B is the maximum induction density—may be relied upon for all kinds of iron. The experiments by means of which Mr. Steinmetz has established his law are exceedingly numerous, and we have not thought it necessary to record them all, as the practical result of the work is completely summarised in the constants found for the different samples of iron tested.

While endeavouring to maintain unbiassed opinions on most controversial matters connected with engineering and science, we may be blamed by some enthusiasts if we allow our impartiality to extend to the metric and decimal question. Two of the most prominent men who have resisted the attempt to decimalize everything are Sir Frederick Bramwell and Mr. Coleman Sellers; but they have been very moderate in the expression of their views, and in this respect contrast favourably with the impetuous spirit which marks the progressive reformer. An extract from an article by Mr. Sellers will be found in another column. We do not believe that the circulars so diligently issued by the Decimal Association carry much weight with manufacturers. We are constantly being told that some semi-barbarous country has adopted the metric system among other fashions of civilization; and that this market or that will only purchase stove pipes that will fit a metrically designed stove, or hatbands a certain number of centimetres in depth. Decimal and metric reformers would consign foot rules to the British Museum; but Mr. Sellers, whose experience as a manufacturer is very large, and who has given the millimetre a fair chance in his factory and found it too troublesome, admits that the metric system is useful in some cases, and advocates the free play of the principle of the survival of the fittest.

If we do not look to the columns of the *Referee* for useful suggestions in electric engineering and apt explanation of scientific phenomena, the fault rests entirely with ourselves. Commenting, as nearly every journal has done, upon Nikola Tesla's experiments, and alluding to the manufacture of light, Lamb's Chinaman who burned down his house in order to provide roast pork is used as an excellent illustration of the

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wastefulness of our present methods of producing light. The commercial value of the vacuum tube illumination is dwelt upon; and the science of the paragraphs, except those which are based on the leading article in *The Times*, is singularly correct for a non-scientific, we will not say non-technical, paper.

THE various ideas which some of the audience carried away from Mr. TESLA's lecture, and which have appeared in the daily papers, are rather strange. One account is that he has discovered what electricity really is, and that he can manufacture a new kind which gives a very pretty light, that he has "invented" vacuum tubes which need no wires; but there is still some doubt as to whether, if we wish to use these for domestic purposes, we must make ourselves "a channel for a current at something like 50,000 volts." The leading article in *The Times*, from which this expression is quoted, is another example of unusually accurate newspaper science. The "at" instead of "of" just avoids the confusion between current and volts, which is so common. But the article goes on to say—"The vacuum tube glows like the gates of sunrise, but the lecturer feels nothing, though a current of one five-hundredths of the intensity might easily terminate his career." Never was that foreign word "intensity" more vaguely used; we owe a serious grudge to the French nation for it.

MR. TESLA himself is, we understand, not quite prepared to admit that the current which passes through the body is the only element of danger to be considered; but it is difficult to see what other factor than current enters into the question, unless it be that of frequency. Two or three milliamperes at ordinary frequencies can be taken without much discomfort; and with such pressures as 100,000 volts, which Messrs. SWINBURNE and Co. often experiment with, it would be very easy, though very foolish, to run a quarter-horse power motor, using the body as part of the circuit.

Bermondsey Vestry.—At the next meeting of this Vestry the surveyor will bring up an estimate of the cost of lighting the streets by electricity.

The Charge of Steam Engines and Boilers.—Notice has been given in the House of Commons of two Bills to require certificates from persons in charge of steam engines and boilers on land.

Coast Communication.—Sir E. Birkbeck has moved to call attention, on March 4th, to the loss of life and property on our coasts and the necessity for improved telegraphic and telephonic communication.

The New Telephone Exchange at Paris.—The Minister of Commerce recently inspected the new telephone exchange now in course of completion in the Rue Gutenberg. The building is entirely composed of iron, stone and glazed brick.

Inverness.—The proposal to light Inverness by electricity has been put aside for a time. At a recent meeting of the Town Council a motion was adopted discharging the committee appointed to investigate the matter, on the ground that the scheme would cost between £30,000 and £40,000. The inquiry cost £143.

The Saunders' Lightning Guard in Operation.—A very severe single shock of lightning and thunder occurred at the Eastern Telegraph Co.'s Station at the Land's End on Tuesday, about 12.5 p.m. Two of Saunders' lightning protectors were fused, probably saving the Lisbon and Vigo cables and instruments. The Malta circuit was not affected.

Glasgow.—At the last meeting of the Corporation, the special committee on electric lighting recommended that the business, heritable property, plant, and machinery belonging to Messrs. Muir, Mavor, Coulson, and Co. should be acquired by the Corporation at the price of £15,000—the Corporation to receive possession on March 1st next. This was approved.

Electric Drills.—Messrs. Bell Brothers, of Middlesborough, have decided to drill by means of electricity in one of their Cleveland ironstone mines. They have previously employed water turbines, oil engines, &c., as a means of working their drills. The drills will be of the Bell, Steavenson, and Clough type, the motors being designed by Messrs. W. T. Goolden & Co.

Larne.—A meeting was held at Larne last week, at which the Town Commissioners explained to the citizens (who had requisitioned the meeting) the steps they had taken to secure the completion of the arrangements with Messrs. Gordon & Co., for the electric lighting of the town. After a lengthy discussion it was resolved that the Commissioners deserved the best thanks of the town for their enterprise and public spirit for introducing the electric light.

Condensers for Electric Light and Power Purposes.—The dielectric employed by Mr. Swinburne in the construction of his electric light and power condensers is, according to a recent patent specification, thin butter-skin paper. The condenser, when built up, is compressed and baked in a suitable oven for several days at a temperature of about 100°C.; it is then immersed in paraffin oil, the vessel containing the condenser being sometimes exhausted before running in the oil to make sure that the liquid finds its way into all the interstices.

Cable Extension.—Another link between the mother country and one of her colonies has been rendered an accomplished fact by the successful completion, on Thursday last week, of the laying of a cable by W. T. Henley's Telegraph Works Company between the Bahamas and Jupiter Inlet, on the Coast of Florida. The Act authorising the construction of the cable was passed last Sesion, and the contract for the manufacture and laying of it was made with the Company, whose cable ship "Westmeath" left England at the end of December last for the Bahamas.

Liverpool.—At the meeting of the Watch Committee of the Liverpool City Council on Monday last, the question of the Provisional Order applied for by the Liverpool Electric Supply Company was under consideration. A letter was read from the solicitors to the Company, expressing willingness to negotiate on the terms suggested at the last Council meeting—namely, that the Corporation should have power to purchase the undertaking at any time after 1896 on giving twelve months' notice to the Company, the purchase to be at a fair valuation as a going concern. No final decision was come to.

Exports of Telegraph Apparatus.—The Board of Trade Returns for January are not satisfactory so far as regards our exports of telegraphic wire, and of apparatus connected therewith. The value of our exports under this head was smaller than in the first month of either 1890 or 1891. The following is a statement for last year and for last month, in comparison with the corresponding periods of the two previous years:—

	1889.	1890.	1891.
Year	£1,038,540 ...	£1,602,205 ...	£1,434,873
	1890.	1891.	1892.
January	£71,686 ...	£238,223 ...	£46,246

Church Services by Telephone.—At the last meeting of the Glasgow Town Council the minutes of the Churches Committee contained the following:—There was submitted a letter from the National Telephone Company stating that they are desirous of connecting several of the leading churches in the city with their telephone exchange, so that their subscribers whose houses are connected with the exchange could hear the services by telephone, and asking permission to place a telephone instrument or instruments in St. George's Church. The committee

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instructed the communication to be transmitted to the kirk-session of the church for their remarks thereon. The minutes were approved.

The Crystal Palace Exhibition.—On Saturday last a large number of electrical engineers and others were invited to the Crystal Palace to meet the Lord Mayor and the Sheriffs of the City of London. Amongst those who accepted the invitation were Mr. Nikola Tesla, Prof. Ayrton, Prof. Crookes, Dr. John Hopkinson, Mr. Preece, Prof. Hughes, Prof. Silvanus Thompson, Prof. Perry, Mr. R. E. Crompton, &c. After the Lord Mayor had made a close inspection of the Exhibition, dinner was served in the Grand Saloon. Mr. Rait, Deputy-Chairman of the Crystal Palace Company, presided. The Lord Mayor proposed the toast "Success to the Exhibition." He referred to the discreditable financing of the electric light of ten years back, and compared the state of things then with the very satisfactory condition of the industry at the present time. Dr. Hopkinson proposed the toast of "Electrical Science and Industry," to which Prof. Ayrton replied in a humorous speech. Mr. Crompton, Mr. Preece, and Mr. Nikola Tesla also spoke.

Heavy Resistances.—Nothing, says *Industries*, seems easier to design than a resistance capable of taking several horse-power, as all that is necessary is a few yards of spiral iron wire. In practice, however, resistances come out expensive and cumbrous articles. There is, however, a very simple way of making resistances which will absorb large powers without trouble. The required resistance is made up in lead wire, and this is immersed in water. Under 100 volts a little of the electricity crosses by the water, so the current cannot be found accurately by dividing the pressure by the resistance of the lead. The lead does not waste, as one side peroxidises and protects itself. It is surprising what large currents can be taken up in this way. For temporary work a piece of platinoid wire can be used. A spiral some 3in. long, consisting of a few feet of wire, placed in a bucket of water, will take two or three horse-power till the water is boiled away. These methods are so very convenient that they should be more widely known among electrical engineers.

Rockhampton (Queensland).—In November, 1889, the Rockhampton Gas and Coke Company procured an Act permitting them to supply electricity for all public and private purposes. The Company recently issued a circular to find out what demand there was likely to be for the electric light. The townspeople responded so well that the Company have decided at once to lay down an electric plant. Distribution will take place on three systems, viz., for 500 yards in each direction from the central station there will be plain 2-wire distribution at 110 volts. Beyond this the system will be that of alternate-current transformers, and for the street lighting there will be the continuous-current series arc system. A 3,000-light plant will be laid down at once. The supply will begin about July next. The whole of the work has been planned, and will be carried out under the supervision of Mr. A. E. Neal, the company's electrical engineer. The price of gas at Rockhampton varies from 7s. 6d. to 12s. 6d. per 1,000ft., and it is proposed to charge 1s. per B.T.U. for electricity.

Cleaning a Telephone Switch Board with an Exhaust Fan.—On the switch board of the Chicago Telephone Company there are some 188,000 contacts to be kept clean. The apparatus employed for this purpose, says the *Western Electrician*, consists of a ¾ H.P. Edison standard motor, belted to a Sturtevant exhaust fan. Connected to the exhaust pipe is a 5in. hose, terminating in a funnel, the edges of which are padded with felt. The hose is of a convenient length, about 6ft. or 7ft. The motor is equipped with a rheostat and receives current through a length of flexible cable that may be attached to the lamp sockets located at various points around the board. All this gear is mounted, so that it may be easily moved about. In cleaning an operator starts the motor, and slides the funnel over the face of the board. The strong suction from the blower draws all dust and particles of foreign matter through and out of the holes, leaving them clean and bright. The funnel is made of such a size as to cover 100 holes at a time, so two sweeps are enough to take in all the holes on one section of the switch board.

A Telegraphic Centenary.—French telegraphists are proposing to celebrate, by the erection of a statue or bust, the centenary of the invention of Claude Chappe's optical telegraph. Before resigning himself to devising a practicable optical system Claude Chappe made several attempts to enlist the services of electricity; but it is considered probable that the want of a good insulator discouraged him. M. A. Boussac, Inspector General of Posts and Telegraphs, who is president of the Centenary committee, remembers the days when Claude Chappe's eight-arm telegraph was still used. Two movements were sufficient to indicate any one of the 10,000 code words known only to the authorities. About 1852 there was a somewhat curious mixture of systems. By means of the Foy-Bréguet system the Chappe code signals were transmitted electrically as far as possible, and where the electric telegraph terminated the messages were transferred to the old semaphores. Claude Chappe's device may, therefore, be reasonably deemed the progenitor of the present telegraphic system of France. Driven out of his mind by the attacks of his rivals, Claude Chappe drowned himself on January 23, 1805.

The London County Council and the Electric Railway Schemes.—A considerable part of the last meeting of the London County Council was occupied in discussing the report of the Parliamentary Committee in regard to the railway and tramway Bills affecting London which are being promoted during the present Session of Parliament. The committee recommended (*a*) that petitions be presented against the Baker-street and Waterloo Railway, the Central London Railway, the City and South London Railway, the Great Northern and City Railway, the Hampstead, St. Pancras, and Charing-cross Railway, and the Waterloo and City Railway, with a view to securing the insertion of clauses prohibiting the companies from bringing forward their buildings beyond the general line of frontage of buildings in streets; (*b*) that Parliament be asked to refer the underground railway schemes of the present Session to a joint committee or to a special select committee, with power to inquire thoroughly into the question of the future railways of Central London. They also recommended a petition against the Ward Electrical Car Company's Bill. The recommendations of the committee were adopted.

University College, London.—In order to afford increased and improved accommodation for the departments of Mechanical and Electrical Engineering, and of Physics, the Council of University College, London, have decided to enter without delay upon a considerable extension of the College buildings. The addition to the College will form an important block opposite the east end of University-street, with an extension for some distance along the Gower-street front of the College grounds. It is to contain separate laboratories and lecture-rooms for Mechanical Engineering and Electrical Engineering, with rooms for engineering drawing, a dynamo room, and all else that is required for an efficient school of modern engineering. This extension will enable the basement and ground floor of the central wing of the main building, together with a new building to be erected in the inner court, to be devoted to the department of Physics, which has hitherto been very imperfectly provided for in rooms that were originally intended for quite other purposes than those to which they have been applied. The position of the new physical laboratory will be such that it will be as far removed, as is easily possible in the heart of London, from heavy street traffic.

Bradford.—At the last meeting of the Town Council, Alderman F. Priestman, in moving the adoption of the minutes of the Gas and Electricity Supply Committee, said he was pleased to be able to say that the anticipations expressed by him a year before had been amply fulfilled. On the income side of the account stood £3,592 for electricity supplied. That left a balance of £2,001 to net revenue account. On that account there was to pay for interest on loans £545, sinking fund £392, income-tax £92, total £1,030, leaving a net profit for the half-year of £971 4s. 10d. Interest and sinking fund had been paid from the very commencement. The first half-year's loss on the concern was £1,079; the second half-year's, £732; the third half-year's, £315; and the fourth half-year's, £30; total, £2,157. After subtracting from that total £971

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profit, a loss of only £1,186 remained. The coal consumed during the half-year was 865 tons. The total cost of that coal had been £342, and the number of Board of Trade units sold was 154,431, so that the cost of coal per Board of Trade unit had been ·58d. The average price of coal had only been 7s. 7d. delivered at the works. He hoped these figures would be closely gone into by the electric lighting journals, and that there might be a discussion upon them, so that it mght be seen whether any other station was better than their own, and, if so, why—in order that if they extended their electric lighting plant they might make any change in the system which might appear desirable.

Military Telephony.—During the monster military manœuvres which took place last autumn, in the east of France, the telephone was, by order of the Minister of War, made extensive use of. Batteries being inadmissable, magnetic telephones were alone employed; the receiver being fastened to the *képi*, while the transmitter was held in the hand. A combined receiver and transmitter (50mm. diameter, 400 grammes weight) was also tried. A naked ·6mm. bimetallic wire was used with an earth return. A good earth was made by sticking a bayonet well into the ground. Mounted soldiers connected the earth wire to their horses' bridles, the current going to earth through the horses' hoofs. Two men formed a telephone detachment. One carried the telephones and a rolling drum weighing 2½ kilogrammes and wound with 1,000 metres of conductor; the other had a light bamboo stick, with a hook at the end and another drum of wire. The two men could thus lay 2 kilometres of line. The man with the telephones walked rapidly along unrolling his wire and his comrade followed and placed it as far as possible out of harm's way on branches, hedges, walls and along trenches. In one experiment a 23-kilometre line, with 10 intermediate posts, was laid down in five hours, speech was perfect, and the whole was taken up again in an hour. Earth contacts seemed to have but little influence. During the sham fight of September 7th, a 12-kilometre line worked without a moment's interruption, although an entire cavalry division passed over it. The cost of the system need not be an obstacle, 10 kilometres of line, 10 drums, 3 telephones, and 5 bamboo rods only costing 185 francs.

Electricity v. Gas.—The following remarks of the Chairman of the Gas Light and Coke Company, at the last meeting of the Company, are of some interest:—"They had very carefully looked into the electric light question as it affected them. The most important electric lighting district was formed of what he might call the Bond-street quadrilateral—Bond-street, Regent-street, Oxford-street, Piccadilly, Pall-mall, and the Strand. Their rental from that district in 1889 was £77,675, when the electric lght was more than beginning to make itself felt; and in 1890 the amount fell to £74,947, and last year to £73,538. They had thus lost in a district which was more electrically lighted than any place in the world £4,000 of rental in three years, while the increase in their rental all over their district for last year alone was £92,000. He might say further that they had got out a list of typical consumers in every part of their district—the Houses of Parliament, Marlborough House, the British Museum, the General Post Office, banks, clubs, places of amusement, and large tradespeople; and he found, dealing with this list of 81 consumers, that the rental which they paid the Company three years ago was £91,363, two years ago the amount was £88,323, and last year it was £87,847. This showed, again, that they had lost £4,000 in three years among all these great consumers of the electric light. He thought they had conclusively proved that the electric light was a light of luxury, and was used only by those who did not care about the question of cost. He might say that out of their 215,000 or 220,000 customers, only 2,600 used the electric light, or less than 1¼ per cent. There was, however, plenty of room for gas, the electric light, oil, and candles."

The Sims-Edison Torpedo.—A trial under way of the Sims-Edison torpedo was made at Portsmouth last week from the steamer "Drudge." In its latest form this torpedo measures 31ft. in length, with a maximum diameter of 20in., and is composed of four water-tight sections. Total weight about 1½ tons. The first compartment contains the charge. In the second compartment is stored the cable. The cable is of Silvertown manufacture, and contains two conductors—an annular one which carries the dynamo current for working the propeller motor, steering the torpedo ahead and exploding the charge, and a central one attached to a secondary battery for deflecting the relays in connection with the electro-magnets which actuate the rudder. In order to secure the necessary flexibility the principal conductor is made up of no fewer than 135 strands. The third section contains an Edison motor, which is a two-pole series-wound machine, running at 1,600 revolutions, and developing 33 H.P. The fourth section contains the shaft for working a two-bladed propeller and the electrical gear for controlling the rudder. On the torpedo being despatched from the "Drudge," which was under easy weigh, it commenced to pay out its 3,000ft. of cable. After exhibiting its amenability to control, the torpedo made an almost complete tour of the ship, and with accelerated speed. Owing, however, to a defect in the dynamo, which reduced the current to 17 amperes instead of 30, and to 750 volts instead of 1,200, the speed at no time reached its previous achievements, when an estimated speed of 20 knots was realised. The whole time from launch to stop was six minutes, so that, with the known length of wire deposited by the torpedo in its course, the approximate speed was 13 knots. The demonstration was, however, sufficient to show that the torpedo was capable of being made a formidable engine of warfare, and to satisfy the visitors that its importance for the purposes of defence ought not to be lost sight of.

Chicago Exhibition.—The Royal Commission inform us that the British colonies promise to be largely represented at Chicago. The amounts voted by the various Colonial Governments already nearly reach £75,000, three times the appropriation made by the Home Government—£25,000—and large additions will be made to this total when the other colonies who have applied for space announce the amounts they intend to spend. Canada, for instance, has not yet decided on her expenditure, though she will make an extensive exhibit. The total area allotted to Great Britain and the colonies will probably be about 300,000 square feet, the largest space ever filled by us at any foreign Exhibition except Paris in 1878 (363,600 square feet), and this will have to be increased by the erection of annexes or otherwise if the demands of the colonies are to be even approximately satisfied. New South Wales has already asked for 300,000, the whole amount available, other known demands come up to another 100,000, and as much may reasonably be demanded for Canada, so that a total area of 500,000 has practically been applied for by the colonists alone, leaving out of the question the requirements of the mother country.—The following letter, which appeared in Saturday's *Standard*, doubtless expresses the views of many others besides the writer:—

SIR: I have just read your very able and interesting article in the *Standard* of to-day, with reference to the approaching Exhibition in Chicago; but regret that I am unable to agree with your conclusion as to the desirability of our English manufacturers making large applications for space. Our American cousins are reputed 'cute; but I question whether they have ever done anything much cooler than this. With one hand they shut out our goods by means of duties varying from 50 to over 2 0 per cent., and with the other they beckon us to come and exhibit in Chicago. What can they mean? They evidently do not want our goods, or they would not try to exclude them with prohibitive tariffs. The answer is simple and sufficient. They want to gather together in Chicago a collection of the best products of all the markets of Europe, with a view to reproducing them in their own country. I think, however, that we have been educators of the world long enough, and observations during a recent visit to the United States convince me that our manufacturers will be wise if they refuse to fall into such a palpable trap, and make up their minds to give Chicago a wide berth in 1893, except as visitors.—I am, Sir, your obedient servant, G. F. ASSINDER.—Liverpool, February 4th.

The Lundy Island Cable.—In view of the increasing agitation for an organised system of coast communication, with branch cables to outlying lighthouses and lightships, the following facts with regard to the old Lundy Island cable are of interest:—Various Chambers of Commerce, the Press, and the pilots of the Bristol Channel, declaring that a cable to Lundy was needed, a Company was formed in 1883, with a capital of £10,000, for the purpose of supplying that need. Mr. G. F. Rogers, of London, agreed to lay the cable, and this was

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done on March 22, 1884, the shore ends weighing 16 tons to the mile, and the main cable nine tons to the mile. The route, from Hartland Point, to Lundy, *viâ* Rat Island, was selected as being the shortest and least expensive. It was soon discovered, however, that being directly in the tideway and on a rocky bottom, the cable was being cut through. The Company secured an annual subsidy of £100 from Lloyd's, who also engaged to establish a signal station, and work the cable at their own expense. Some 60,000 vessels pass the island each year, and it was thought that they would be glad to avail themselves of the opportunity of reporting their whereabouts. The Company were to receive a royalty of two shillings on every message, so that it was anticipated that a fair dividend might be realised and a sinking fund created. Shipowners, however, forgot their promises of support, and shipmasters in many cases either ignored the pennant hoisted at the signal station, or signalled the watchmen not to report them. The Company, in fact, received little else than the subsidy from Lloyd's, and at length, with a broken cable, and broken fortunes, they wound up their affairs. The cable was resold to Mr. Rogers. He had it taken up in the spring of 1891, and removed to London, where it has been thoroughly overhauled and repaired. If a new company, or any public authority, wished to revive telegraphic communication with the island, they would be well advised not to relay it across the tideway, but by a more oblique route to Braunton. At present a ship may be safely anchored at Lundy ; and the owner, unable to obtain information of her whereabouts, may be effecting insurances at ruinous premiums.

Cylinder Oils.—In lubricating steam-engine cylinders, says the *Chemical Trade Journal*, there are two conditions present which are not met with in any other machinery ; these conditions are a high temperature and water. Although water at ordinary temperatures has no action on oils, yet at high temperatures its action is different, especially with the fatty oils. These, when subjected to the combined action of water and high temperature, are decomposed into their two constituent parts, the fatty acids characteristic of the oil or fat and glycerine. The latter passes away with the exhaust, the former remain behind, caking and corroding the cylinder. Hydrocarbon oils have therefore almost entirely displaced fatty oils for lubricating cylinders. Hydrocarbon cylinder oils are almost entirely derived from American petroleum. They are of two classes, the black and the more highly refined green. The crude petroleum is first filtered, then refined by distillation with heat and super-heated steam. The residue is then cooled artificially, and the paraffin which crystallises out, separated by filtration, the residue being sent out as cylinder oil. When a green oil is required, the black oil is taken, filtered again and again through animal charcoal, as well as being treated with caustic soda and sulphuric acid to get all the impurities out of it. The consistency of these cylinder oils is very variable ; their specific gravity averages about 0·890 to 0·895, but is unimportant and is no guide to quality. The flashing point ranges from 530° F. to 580° F. Flash points in cylinder oils are a matter of little moment. Given other more essential properties, an oil of a flash point over 400° F. is safe enough. The property which a cylinder oil should possess above all others, and the one which should be made the standard, is viscosity : if its viscosity is low, its lubricating power is low too ; on the other hand, given great viscosity, then the lubricating power must be good. In the case of cylinder oils especially, the oil must not only have a good viscosity at the ordinary temperature, but it must not lose it in too great a degree when heated. One with a viscosity of 140 (according to Hurst's Standard Viscometer) at a temperature of 180° F. might perhaps be taken as a standard.

The Glasgow Tramway System.—At the last meeting of the Glasgow Town Council a statement was submitted by the Tramways Committee, showing the cost of tramway traction by various systems of haulage :—*Animal traction.* For the year ended 1890, traction on the Glasgow tramways, including maintenance and renewal of the plant therewith connected, in so far as that can be ascertained from the published accounts, cost 6·031 pence per car mile. *Electric traction by accumulators.* The cost of working, based on offers received, and adding thereto the further charges necessary to cover outlays corresponding to these embraced in the cost of animal traction, and also interest at 5 per cent. on the excess of capital required for working by accumulators as compared with animal haulage, amounts to 4·951 pence per car mile. *Cable power traction.* The cost of working, based on offers received, and adding thereto the further charges and interest as before stated, amounts to 5·053 pence per car mile. It would thus appear, the Report goes on to state, that mechanical power by electric accumulators is fully a penny per car mile run less than animal traction, and by cable haulage, on an extended system, there is a saving of rather under a penny per car mile run. Mechanical haulage should be less liable to increased cost from such incidents as are liable to affect animal haulage. For example, provender for the horses on the Glasgow tramways has cost, for the half-year ended December 31, 1891, fully 21 per cent. more than in the half-year ended December 31, 1890, and it is the cost for the year 1890 on which the foregoing figures have been prepared. The increased cost per car mile for provender alone will be about one-third of a penny per car mile run. Of course the cost for animal haulage in Glasgow is an ascertained fact. The cost of mechanical haulage, as before given, although mainly based on offers received, has nevertheless some items, such as maintenance of track, &c., which can be actually ascertained only when such systems of haulage have been in use for some time, but the margin of about a penny per car mile in favour of mechanical haulage should be an ample allowance for such contingencies. The receipts on tramways worked by mechanical haulage are, as a rule, greater per car mile than on cars worked by animal power. The minutes were approved.

Electric Railway Schemes for the Metropolis.—The Parliamentary estimates for the construction of the proposed railway from Waterloo to Baker-street have been prepared in accordance with the Standing Orders of the House of Commons. These estimates, which are signed by Messrs. Galbraith and Church, the engineers to the London and South-Western Railway Company, and Mr. J. H. Greathead, set down the total cost of constructing this line, including £32,000 for contingencies, at £990,000, or at the rate of just under £330,000 per mile, the total length of the proposed railway being three miles six chains. The cost of the actual tunnelling is estimated at £438,435. The erection of the stations will absorb £189,500, whilst laying down the permanent way is estimated to cost £5,000 per mile.—The Parliamentary estimates for the construction of the proposed underground railway from near Waterloo Station to Mansion House-street have also been duly deposited by the promoters. These estimates set out the length of the line as 1 mile 4 furlongs 6·80 chains, and the total cost of construction at £499,769, or at the rate of about £333,178 per mile. Of this sum it is estimated that £144,300 will be required for the acquisition of land and buildings. The cost of tunnelling is set down at £208,615 ; the erection of stations at £66,500 ; and for general contingencies a sum of £46,365 is allowed. These estimates are signed by the same engineers as the Baker-street and Waterloo Railway scheme.—The promoters of the proposed Hampstead, St. Pancras, and Charing Cross Railway scheme have also deposited the Parliamentary estimates for the construction of this railway, prepared by Sir Douglas Fox, C.E., and Mr. J. H. Greathead, C.E. The total cost of constructing this line, with all subsidiary works, is estimated at £1,255,815, of which £1,030,656 is for the main line, 4 miles 4 furlongs in length, from Charing-cross to High-street, Hampstead ; £185,809 for the short line, 6 furlongs 4 chains in length, from under the Hampstead-road to the King's-cross Station of the Great Northern Railway ; £7,150 for the subway under the Strand to connect with the Charing-cross Station of the South-Eastern Railway ; and £2,200 for a bridge for foot passengers between St. Pancras and King's-cross Stations. Of the total cost, it is estimated that £729,860 will be expended in the actual tunnelling. The acquisition of land and buildings will, it is estimated, cost £240,000 ; the construction of stations, £107,100 ; and for general contingencies a sum of £118,170 is allowed.

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ELECTROMAGNETIC THEORY.—XXIV.

BY OLIVER HEAVISIDE.

(Continued from page 321.)

§ 119. It is now desirable to say a few words regarding the method of treating vector differentiation employed by Hamilton, and followed by Tait. The latter speaks in his treatise (chapter I., § 33, third edition) of the novel difficulties that arise in quaternion differentiation; and remarks that it is a striking circumstance, when we consider the way in which Newton's original methods in the differential calculus have been decried, to find that Hamilton was *obliged* to employ them, and not the more modern forms, in order to overcome the characteristic difficulties of quaternion differentation. (For the word "quaternion," we may read vector or vectorial here, because a vector is considered by Hamilton and Tait to be a quaternion, or is often counted as one. This practice is sometimes confusing. Thus the important physical operator ∇ is called a quaternion operator. It is really a vector. It is as unfair to call a vector a quaternion as to call a man a quadruped; although, four including two, the quadruped might be held (in the matter of legs) to include the biped, or, indeed, the triped, which would be more analogous to a vector. It is also often inconvenient that the name of the science, viz., Quaternions, should be a mere repetition of the name of the operator. There is some gain in clearness by preserving the name "quaternion" for the real quaternion—the quadruped, that is to say.) The matter is illustrated by the motion of a point along a curve. But it does not appear, from this illustration, where the obligation to depart from common usage comes in.

The subject is, however, returned to more generally in Chapter IV., on Differentiation, where we are informed that we "require to employ a definition of a differential somewhat different from the ordinary one, but coinciding with it when applied to functions of mere scalar variables." Here again, however, a most searching examination fails to show me the necessity of the requirement; or, at least, that the necessity is demonstrated.

To examine this matter, consider for simplicity a function u of a single scalar variable a and a single vector variable $\mathbf{r}$, say

$$u = f(\mathbf{r}, a).$$

Following the common method of infinitesimal differentials, we have

$$du = f(\mathbf{r} + d\mathbf{r}, a + da) - f(\mathbf{r}, a). \quad . \quad . \quad . \quad (91)$$

That is, on giving the infinitesimal increments $d\mathbf{r}$ and da to $\mathbf{r}$ and a we produce the infinitesimal increment du in the function. Here du, $d\mathbf{r}$ and da are the differentials, and it is important to remark, in connection with the following, that they are infinitesimal, and that du is really the increment corresponding to $d\mathbf{r}$ and da.

Now, Hamiltonian differentials have a different meaning. Though they would be denoted by du, $d\mathbf{r}$ and da, yet, being different, we shall here dignify them with brackets, and denote them by (du), $(d\mathbf{r})$, and (da), to distinguish them from the differentials in (91). The Hamiltonian differential (du) is then defined by

$$(du) = n\left[f\left(\mathbf{r} + \frac{(d\mathbf{r})}{n}, a + \frac{(da)}{n}\right) - f(\mathbf{r}, a)\right], \quad . \quad (92)$$

on the understanding that n is infinity, and that (on which stress is laid) the differentials $(d\mathbf{r})$ and (da) are finite and perfectly arbitrary.

That this process is circuitous is obvious, but is it necessary? Let us examine into its meaning, and compare (92) with (91). First, divide (92) by n. We then have

$$\frac{(du)}{n} = f\left(\mathbf{r} + \frac{(d\mathbf{r})}{n}, a + \frac{(da)}{n}\right) - f(\mathbf{r}, a). \quad . \quad . \quad (93)$$

Now, we see at a glance, that (93) and (91) become identical if

$$da = \frac{(da)}{n}, \quad d\mathbf{r} = \frac{(d\mathbf{r})}{n}, \quad du = \frac{(du)}{n} \quad . \quad . \quad (94)$$

The division of the finite differentials (da) and $(d\mathbf{r})$ by n produces infinitesimal results, and the finite differential (du) is similarly reduced to an infinitesimal. Why then not employ the infinitesimal differentials at once, and avoid the circuitousness?

When we proceed to form a differential coefficient, as du/dt, if $\mathbf{r}$ and a are functions of t, or du/da, if $\mathbf{r}$ is a function of a, we see that their values are equivalently expressed by $(du)/(dt)$ and $(du)/(da)$, using the finite differentials; because this merely says that the value of the fraction du/dt is unaffected when the numerator and denominator are each multiplied by the same quantity.

In the above, the reasoning is the same, whether u is a scalar or a vector function of $\mathbf{r}$ and a.

But whilst the differential coefficient comes out the same, yet the differential (du) is not the increment in u belonging to the finite increments $(d\mathbf{r})$ and (da), nor is it anything like it, exceptions excepted.

The above is as fair and as clear a statement as I can make of the difference between common and finite differentials as applied to vectors; and we see that the Hamiltonian plan is only a roundabout and rather confusing way of expressing what is done instantly with infinitesimal differentials. But then the Hamiltonian plan is said to be obligatory. There's the rub! I can only give my own personal experience. After muddling my way somehow through the lamentable quaternionic Chapter II., the third chapter was tolerably easy; but at the fourth I stuck again, on this very matter of the obligatory nature of the finite differentials. I am no wiser now about it than I was then. Perhaps there is some very profound and occult mystery involved which cannot be revealed to the vulgar in a treatise; Hamilton is a name to conjure by. Or perhaps I "began the study of quaternions too soon!" Or perhaps it is only a fad, after all. Anyway, I am willing to learn, and if I live long enough, may reach a suitable age. At present let us return to common infinitesimal differentials.

§ 120. Although we may employ the method of differentials in any equation involving vectors, using the symbol d, and although we may turn it into an equation of differential coefficients by changing d to the scalar differentiator d/dt (for example), as in § 116, yet we cannot usually turn differentials into differential coefficients when the variable is a vector. This is not because we cannot form the expressions $du/d\mathbf{r}$ or $d\mathbf{R}/d\mathbf{r}$, but because they are not differential coefficients when the denominators are vector differentials. This will be easily seen from typical examples. (The failure has nothing to do with the previous question of finiteness or otherwise of differentials.) Let

$$u = \mathbf{ab}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (95)$$

and let the vector $\mathbf{b}$ vary. Then,

$$du = \mathbf{a}\,d\mathbf{b}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (96)$$

and, therefore, $$\frac{du}{d\mathbf{b}} = (d\mathbf{b})^{-1}(\mathbf{a}\,d\mathbf{b}) = (d\mathbf{b})_1[\mathbf{a}(d\mathbf{b})_1], \quad . \quad . \quad (97)$$

where $(d\mathbf{b})_1$ means the unit $d\mathbf{b}$. Here the imitation differential coefficient $du/d\mathbf{b}$ is a fraud, because its expression on the right side of (97) is not *clear of the differential* $d\mathbf{b}$, whose direction it involves. Nor is equation (97) of any particular use, compared with (96).

Again, in the vector equation

$$\mathbf{R} = \mathrm{V}\mathbf{ab} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (98)$$

let $\mathbf{b}$ be variable. Here we have

$$d\mathbf{R} = \mathrm{V}\mathbf{a}\,d\mathbf{b}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (99)$$

and from this equation of differentials we may form $d\mathbf{R}/d\mathbf{b}$ and $\mathrm{V}\,d\mathbf{R}/d\mathbf{b}$; but neither of them, nor any combination of them, is a differential coefficient clear of differentials. Thus,

$$\frac{d\mathbf{R}}{d\mathbf{b}} = (d\mathbf{b})^{-1}\mathrm{V}\mathbf{a}\,d\mathbf{b} = (d\mathbf{b})_1\mathrm{V}\mathbf{a}(d\mathbf{b})_1 \quad . \quad . \quad (100)$$

contains the differential on the right side. And

$$\mathrm{V}\frac{d\mathbf{R}}{d\mathbf{b}} = \mathrm{V}\,d\mathbf{R}(d\mathbf{b})^{-1} = -\mathrm{V}(d\mathbf{b})^{-1}\mathrm{V}\mathbf{a}\,d\mathbf{b} = -\mathrm{V}(d\mathbf{b})_1\mathrm{V}\mathbf{a}(d\mathbf{b})_1 \quad (101)$$

also contains the differential. As a special result the value of (100) is zero (a parallelepiped in a plane): and by equation (52) we may develope (101) to

$$(d\mathbf{b})_1\{\mathbf{a}(d\mathbf{b})_1\} - \mathbf{a}. \quad . \quad . \quad . \quad . \quad (102)$$

But it is (99) that is the really useful fundamental equation,

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the developments (100) to (102) being useless for differentiating purposes, although true and interpretable geometrically.

Generally, if

$$\mathbf{R} = \mathbf{i}R_1 + \mathbf{j}R_2 + \mathbf{k}R_3 \quad . \quad . \quad . \quad . \quad (103)$$

is a function of

$$\mathbf{r} = \mathbf{i}x + \mathbf{j}y + \mathbf{k}z, \quad . \quad . \quad . \quad . \quad . \quad (104)$$

then R_1, R_2, R_3 are functions, usually different, of x, y and z, and the ratio of $d\mathbf{R}$ to $d\mathbf{r}$ (even in the most general quater, nionic sense), cannot possibly be freed of the differentials dx, dy, dz.

Even when we reduce the generality of the problem by making $\mathbf{R}$ and $\mathbf{r}$ coplanar, say in the plane of $\mathbf{i}$, $\mathbf{j}$, with $z = 0$ and $R_3 = 0$, $d\mathbf{R}/d\mathbf{r}$ is not usually a definite differential coefficient. It only becomes one by special relations between the differential coefficients of R_1 and R_2 with respect to x and y, viz :—

$$\frac{dR_1}{dx} = \frac{dR_2}{dy}, \qquad \frac{dR_1}{dy} = -\frac{dR_2}{dx} \quad . \quad . \quad . \quad (105)$$

This is the vectorial basis of the large and important branch of modern mathematics called the Theory of Functions, which appears in electric and magnetic bidimensional problems.

§ 121. Sometimes it is convenient to have the variation of a vector exhibited in terms of the variations of its tensor and unit vector, or its size and ort. Thus, from

$$\mathbf{R} = R\mathbf{R}_1,$$

we produce, by differentiating,

$$d\mathbf{R} = Rd\mathbf{R}_1 + \mathbf{R}_1 dR. \quad . \quad . \quad . \quad . \quad (106)$$

If there be no variation of direction, then

$$d\mathbf{R} = \mathbf{R}_1 dR\,; \quad . \quad . \quad . \quad . \quad . \quad (107)$$

and if the tensor does not vary, whilst the direction does, then

$$d\mathbf{R} = Rd\mathbf{R}_1. \quad . \quad . \quad . \quad . \quad . \quad (108)$$

Dividing (107) by the scalar $d\mathbf{R}$, we get a proper differential coefficient

$$\frac{d\mathbf{R}}{d\mathbf{R}} = \mathbf{R}_1, \quad . \quad . \quad . \quad . \quad . \quad . \quad (109)$$

provided $d\mathbf{R}_1 = 0$. From (108),

$$\frac{d\mathbf{R}}{d\mathbf{R}_1} = \mathrm{R}, \qquad \mathrm{V}\frac{d\mathbf{R}}{d\mathbf{R}_1} = 0, \quad . \quad . \quad . \quad (110)$$

provided $d\mathrm{R} = 0$, which makes $d\mathbf{R}$ perpendicular to $\mathbf{R}$. But it is as well to avoid forms of this kind (with a vector variation in the denominator), even when by some limitation, as above, we can get rid of the differential. Of course, in (106), without any limitation, we can change d to d/dt (or other scalar differentiator) thus

$$\dot{\mathbf{R}} = R\dot{\mathbf{R}}_1 + \mathbf{R}_1\dot{R}. \quad . \quad . \quad . \quad . \quad . \quad (111)$$

It is this (scalar) kind of differentiation that nearly always occurs in physical applications, and there is no abstrusity about it. See § 116. Nor is there about differentials, provided we do not attempt to make differential coefficients with respect to vectors, or make the differentials themselves finite.

We have also $\mathbf{R}^2 = \mathrm{R}^2$,

which, on differentiation, gives

$$\mathbf{R}d\mathbf{R} = Rd\mathrm{R}\,; \quad . \quad . \quad . \quad . \quad . \quad (112)$$

or, dividing by R,

$$d\mathrm{R} = \mathbf{R}_1 d\mathbf{R}, \quad . \quad . \quad . \quad . \quad . \quad (113)$$

which says that the increment in the tensor is the component along the vector of its vector change $d\mathbf{R}$, whose full expression is given by (106). Using (106) in (113) we get

$$\mathbf{R}_1 d\mathbf{R}_1 = 0. \quad . \quad . \quad . \quad . \quad . \quad . \quad (114)$$

Using (113) in (106) we get

$$d\mathbf{R} = Rd\mathbf{R}_1 + \mathbf{R}_1(\mathbf{R}_1 d\mathbf{R}), \quad . \quad . \quad . \quad (115)$$

or, dividing by R,

$$\frac{d\mathbf{R}}{R} = d\mathbf{R}_1 + \frac{\mathbf{R}_1 d\mathbf{R}}{R}, \quad . \quad . \quad . \quad . \quad (116)$$

all of which results may be geometrically interpreted.

In differentiating the reciprocal of a vector, proceed thus :—

$$d\frac{1}{\mathbf{R}} = d\frac{\mathbf{R}_1}{R} = \mathbf{R}_1 d\frac{1}{R} + \frac{d\mathbf{R}_1}{R}, \quad . \quad . \quad (117)$$

where, for d may be written d/dt, &c.

Another way is

$$d\frac{1}{\mathbf{R}} = d\frac{\mathbf{R}}{R^2} = \frac{d\mathbf{R}}{R^2} + \mathbf{R}d\frac{1}{R^2}. \quad . \quad . \quad . \quad . \quad (118)$$

It may easily be shown, by (106), that these results are equivalent.

Enough has now been said about the meaning and effect of differentiating vectors. The important vector differentiator ∇ deserves and demands a separate treatment.

(To be continued.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-NIGHT) FRIDAY, February 12th.

PHYSICAL SOCIETY.

5 p.m. Annual General Meeting. After which the following Papers will be read: "On Supplementary Colours," and "On Modes of Representing Electromotive Forces and Currents in Diagrams." By Prof. Silvanus Thompson, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

7:30 p.m. Students' Meeting at the offices of the Institution. Paper to be read: "Some Notes on Electroplating." By H. B. Little.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read: "Fly-Wheels and Governors." By H. B. Ransom, Stud.Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening discourse: "Rain, Snow, and Hail." By G. J. Symons, F.R.S.

SATURDAY, February 13th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Matter at Rest and in Motion." By Lord Rayleigh, F.R.S.

MONDAY, February 15th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. II.—4. "Developments of Electrical Distribution." By Prof. George Forbes, F.R.S.

TUESDAY, February 16th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. The Discussion upon the following Paper to be continued and concluded: "Gold Quartz Reduction Machinery." By Alfred Harper Curtis, Assoc.M.Inst.C.E.

SOCIETY OF ARTS.

8 p.m. Paper to be read: "The Forthcoming Exhibition at Kimberley, South Africa." By Lewis Atkinson.

WEDNESDAY, February 17th.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting. Papers to be read: (1) "Report on the Phenological Observations for 1891." By Edward Mawley, F.R.Met.Soc. (2) "The Untenability of an Atmospheric Hypothesis of Epidemics." By the Hon. F. A. Rollo Russell, F.R.Met.Soc. (3) "The Origin of Influenza Epidemics." By Henry Harries, F.R.Met.Soc. (4) "Note on a Lightning Discharge at Thornbury, Gloucestershire, July 22, 1891." By Ernest H. Cook, D.Sc.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "The Pamirs." By Capt. F. E. Younghusband.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Presidential Address by Dr. R. Braithwaite.

THURSDAY, February 18th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting.

CHEMICAL SOCIETY.

8 p.m. Ballot for Election of Fellows. Papers.

FRIDAY, February 19th.

INSTITUTION OF CIVIL ENGINEERS.

1.30 p.m. Students' Visit to the Works of the Chelsea and Lambeth Water Companies, at Molesey, and subsequently to those of the Grand Junction, Southwark and Vauxhall, and West Middlesex Water Companies, at Hampton.

ROYAL INSTITUTION.

9 p.m. Friday Evening Discourse: "Micro-Organisms in their relation to Chemical Change." By Prof. Percy F. Frankland, F.R.S.

SATURDAY, February 20th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Matter at Rest and in Motion." By Lord Rayleigh, F.R.S.

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COAST COMMUNICATION.

The wreck of the "Eider" has once more called attention to the urgent necessity for telegraphic and telephonic communication between lighthouses, lightships, and coastguard stations, and to the utter inability of even our most powerful lights to pierce a few miles of fog. Both subjects have been repeatedly dwelt upon in these columns. As to coast communication, those of our readers who have given the most cursory attention to the matter are probably aware that the Post Office has long ago formulated a complete scheme for connecting all needful points with their main lines. The result of the deputation to the Board of Trade in June last elicited some satisfactory admissions of sympathy; but the everlasting "non possumus" and the polite reference to some other Government department, formed then the chief burden of Sir MICHAEL HICKS-BEACH'S reply. The saddling of the responsibility upon any particular department was avoided with a skill worthy of a better cause. The Board of Trade had nothing to do with the Coastguard Service, the Coastguard being under the Admiralty. But Sir MICHAEL HICKS-BEACH warned the deputation, lest in a moment of enthusiasm they might be so foolish as to waste time in attempting to get the ear of the Admiralty, that the expense would have to be borne by the Treasury, and definitely recommended them to approach that department. We are not aware whether they acted on this advice; but, at any rate, it would appear from a recent semi-official note communicated to the Press, and from

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the remarks of the President of the Board of Trade at the banquet of the Chamber of Shipping of the United Kingdom, that an inquiry will be granted.

An immediate and effective improvement in our coast communications is rendered imperative from three points of view—humanity, the safety of our shores in time of war, and the needs of our mercantile marine, one and all, call for a new departure. Indeed, a mistake has perhaps been made in plying wearied Government officials with too many reasons, and in mixing commercial with humanitarian motives. The "Sunk" lightship trials have been dubbed a failure because a good committee reported that electrical communication could be established in such positions; but that the cable service should be discontinued as having been of no real service during the four years over which the experiment lasted. The extension of ordinary ship-signalling has been suggested; but to urge this is only to afford an excellent excuse, which will be seized on at once by the Treasury, that Lloyd's or those responsible for the allocation of the Mercantile Marine Fund ought to see to the whole matter. The admirable telephonic line on the coast of Denmark, by which lighthouses, lifeboat stations, and rocket stations are placed in direct communication with each other, and with the telegraphic system of the country, is largely used by fishermen to convey information about passing shoals of fish, markets and prices, and other matters connected with the fishing industry. But it would never do to bring this forward in attempting to get the Admiralty to move. What has that department to do with fishing-boats except as impertinent intruders on their practice ranges? They would refer the matter to the County Councils. It is estimated that £100,000 would suffice for connecting the stations on the coast with the telegraph system of the United Kingdom. The Navy estimates for 1890-91 included £236,971 for "gun-mountings and torpedo carriages and gear," besides £90,000 for "electrical, torpedo and other apparatus." The estimates for 1891-92 for the same items are £251,000 and £70,000 respectively. Some 700 lives are lost every year not upon the high sea, but close at home on our shores among the rocks and breakers. Mr. Robert Bayly and others have recorded scores of cases in which lighthouse keepers and coastguards have been eye witnesses of awful disasters, but have been either absolutely unable to help, or have been reduced to a vain endeavour to call out the nearest lifeboat, perhaps miles away, by a foot messenger More lives might be saved by the expenditure of this £100,000 than will ever be destroyed by the Brennan torpedo, on which so many thousands have been squandered.

It is argued by officials and others that this most needful extension of the electric telegraph would take away coastguard men and lighthouse keepers from their proper duties. What are their proper duties? The coastguard service already undertakes a variety of duties, some of which have no more connection with naval matters than the probate or divorce matters which are associated with the Admiralty in the Law Courts. It was not until 1856 that the coastguards were transferred to the Admiralty; and even now their incessant patrol of the coast is in the interests of the Inland Revenue and in keeping a lookout for wrecks, rather than in actual Admiralty service. One of the attainments of which most coastguardsmen are justly proud is their skill in signalling. No army "flag-wagging" can compete in speed with the simple semaphore system which many of them employ every day. At the same time they have a good knowledge of the Morse code, and most of them can handle a Morse key and read a Sounder. Telephonic and telegraphic communication between coastguard stations, lighthouses, and lifeboat stations, even if the isolated lighthouses and lightships were not connected, would be of immense service in procuring and arranging help, and the cost of maintenance would be trifling. To connect our rock lighthouses and exposed lightships by cable with the mainland would be a far more costly and difficult task; but we have heard of no experiment which can be said to demonstrate its impossibility. Telephonic and telegraphic communication cannot as yet be satisfactorily carried on without any wire at all; but enough has been done to show that nothing short of a complete rupture need stop transmission over short lengths of line.

As to the question of how best to increase the penetrative power of our coast lights in time of fog, there seems little else to suggest but experiment—persistent experiment. The material and other less substantial rewards which would attend a complete solution of the problem should spur the efforts of scientific men. Prof. Tyndall has recently put forward the idea of causing "sudden and powerful flashes of light to impinge upon fog;" practical mariners favour the idea of a vertical beam; others have proposed an alteration in the colour of the light. Our knowledge of the atmospheric conditions which obtain in time of fog is too meagre to make one suggestion more feasible than another. But the importance of overthrowing the dominion of King Fog renders the cost of continued experimentation a secondary matter.

NOTES ON SUBMARINE CABLE WORK.

BY H. D. WILKINSON.

Introductory.

It is proposed in these notes to describe the procedure on board ship when removing a fault or break in a submerged cable, and the mechanical gear used in different vessels for this purpose. Further, as regards the electrical tests in use for the detection and localisation of faults, to consider the best and most recent practice, and the various difficulties that occur to the beginner. With a total length of 136,000 miles of cable submerged, and a fleet of 36 steamers employed solely in laying and repairing cable, some idea may be gained of the vastness and importance of this enterprise, and the various interests it involves. Of late years many improvements have been introduced in the tests used for locating the positions of faults in cables, and these have meant a considerable saving to the various companies in cost of maintenance. With a vessel, say, of only 300 nominal horse-power, where the coal bill alone amounts to 25 tons per day, the fact of saving a week on repairs by good methods and machinery is of no small importance to a company and its shareholders.

Before entering into the details of ship practice, it may be as well in this introduction to enumerate some of the more salient points in the electrical tests employed, as they are likely to impress the beginner, and to make some allusion to the kind of improvements that have recently been introduced. In the first place, the method devised by Sir Henry Mance, in which the interfering effects of polarisation and earth currents are neutralised without the necessity of reading to false zero, marked a distinct advance on that of Lumsden, if only for the reason that the test could be carried out with the current in one direction only, while the latter required reversals, and therefore the greatest care in avoiding errors due to deposition of salts at the fault.

Further, the means of localising partial earth faults without the assistance of a return cable have been greatly improved by two methods. The Blavier test has long been known to yield doubtful results by itself, especially when the fault is near the testing end, but it serves the purpose of giving preliminary approximations for use in the more accurate methods. One of these improved methods is the earth overlap of Messrs. James Anderson and A. E. Kennelly, who add a resistance to the cable on the faulty side, so that the testing currents from both

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ends of the line encounter equal resistances on each side of the fault. Two such readings with the distant end earthed, and similar battery powers each end, give results which approach very closely the conditions and accuracy of the Varley loop. Mr. H. Kingsford, in another method, tests from one end only, as in the Blavier, but adds a resistance to the line, when the distant end is free, such that the current through the fault is the same strength as when the cable is earthed. In both these methods the principle involved in the improvement consists in maintaining the resistance of the fault constant during a pair of observations under different conditions; and this is done by using the same strength of current through the fault in the two cases. It has long been known that an increase in the testing battery power reduces the resistance of a fault, but it was not until the above methods were devised that the change in resistance of the fault caused by a difference in current passing through it, in two observations, was taken account of. Again, Mr. Kennelly has made a great advance by his discovery of the law connecting the resistance and exposed area of conductor in sea water, with the strength of current passing through the exposure. While not applicable to small faults, where the free evolution of gas is prevented by the adhering deposition of salts, it has proved of the greatest value and service in the localisation of total breaks or fractures of the cable. Mr. Kennelly has also modified the method in such a manner as to exclude all chances of error in observing the false zero, by working to true zero with one additional observation on the bridge.

While these improved methods in localisation are most generally used when a fault presents itself, it is often advantageous to use some of the older methods in order to check the results. And not only for this reason but perhaps, what is more to the point, for the sake of observing the behaviour of the fault. It is on the behaviour of the fault as indicated by the movements of the spot of light on the scale that old practitioners chiefly rely for arriving at an estimate of the fault's resistance. The steadiness or otherwise of a balance, the appearance or not of polarisation with a zinc current, and the rapidity of polarisation with a copper current are points beyond the mere figures read off from the Wheatstone bridge which it is desirable to notice, for, by these effects a pretty fair idea can be formed of the size of the fault and the amount of resistance to allow for it.

It is, of course, the best practice, when time permits, to test by three or more different methods as a check on each other, and it is, therefore, necessary to keep familiar with all the most approved methods. There is generally time to carry out a reliable series of tests by more than one method on shore before the ship is able to reach the position and require watch kept on the line, and also on board ship when picking up to the fault; but it frequently happens during repairs in deep water or rough weather that a bridge test is limited to a minute or 30 seconds on account of the dangerous strain on the cable when both ends are hanging to the ship. It is, therefore, desirable to attain a certain degree of smartness in using the bridge and keys, although, of course, reliability must be the first consideration.

Opportunities are generally afforded to men on the general staff at a cable station, who are so inclined, to carry out tests on the cables. The first practice is usually on cables in good condition, where the resistances of the conductor and insulator are periodically tested. The records of the state of insulation of a cable, kept in this manner, are particularly useful in giving due warning of any cause at work tending to bring about a fault. Signalling can generally be carried on with more or less difficulty through a cable with a fault making only partial earth; and it frequently happens that no appreciable difference is observable in the signals when the starting of a small fault has considerably lowered the insulation resistance. In such cases, therefore, the periodical test gives notice of the incipient stages of a fault, where the signals transmitted would not do so until the fault is considerably developed, and it is often located a sufficient time beforehand for its removal to be effected before it become a cause of serious delay to the traffic. The first thing to do when the periodical tests show a fall in the insulation is to free at the cable house, and make sure that the defect is not in the land line, and ask the other end to do the same.

The records of the conductor resistance tests are chiefly of use in furnishing the correct resistance per knot required in localising any fault that may occur. It is customary for the ship, after effecting a repair, to inform the stations at either end of the corresponding increase in length of the cable, and with this corrected length the resistance per knot of the conductor and capacity per knot of the dielectric are determined anew and confirmed periodically. A cable when first laid is made up of at least three different types, and may have other types differing in resistance and capacity spliced into it at the time of laying. The paying-out log, together with the cable chart, furnish accurate information of this, while after a repair has been effected the type of cable inserted is always entered on the splice list. While differing in types it is of considerable assistance to have the mean resistance and capacity throughout the entire length.

The resistances of the conductor and insulator are usually measured by the bridge and deflection tests respectively. In carrying out these tests an acquaintance is made with earth currents, steady or otherwise, most frequently otherwise, which are generally prevalent in cables even when insulated at one end.

The conductor resistance test, on a perfect cable, when interfered with by an earth current, affords excellent practice of the kind afterwards required in fault testing. The interfering current, when unsteady, has to be watched by itself before and after balances are attained on the bridge, in order to judge a fair mean to allow for a false zero, and good practice can in this way be made of balancing to false zero. Acquaintance is also made with the fact that results can be arrived at within closer limits of accuracy, when the resistances in the fixed arms of the bridge (or ratio arms) correspond most closely to the resistance of the cable. Also, after some amount of usage of the bridge, the numbers representing the various adjustable resistances become familiar, and their places known, so that the operation of shifting the plugs to get balance is more quickly performed, and the final result read off by a glance at what plugs are out. A modification of the conductor resistance test, when interfered with by earth currents, has been adapted from the Mance method by Mr. Kennelly, and consists in taking pairs of readings with different bridge ratios, and so arranging the electromotive force or resistance in the testing battery circuit that one observation in each pair is taken with the strength of current to line twice that in the other. By this means, as in the Mance method, the earth current interference is neutralised, only one direction of current to line is used, and the balance is adjusted to true zero, while the formula is very simple to work from.

Further, in determining the insulation resistance of a working cable, acquaintance is made with the electrification effect by which the insulating material appears to increase in resistance as the current is kept on. The earth current has again to be noticed and allowed for by adding or subtracting the amount of its deflection from that due to the cable, while some calculations in shunts generally come in, and temperature corrections for the resistance of the galvanometer. In these tests, dexterity is acquired in the use of the galvanometer short-circuit key, in bringing the spot of light up to its deflection or back to zero again, without a number of inconvenient oscillations, and in preventing the strong momentary currents due to charge and discharge, or the continuous currents due to want of balance on the bridge from passing through the galvanometer. The use of this key in false zero testing is most important. In bridge work, in order to see whether a given balance is correct to false zero, the galvanometer is short-circuited for an instant while the testing current is cut off, and the cable discharge dissipated, and then thrown into circuit again by the key to observe the position of false zero. More is done by tapping this key with the fingers than anything else, and the necessary dexterity is only acquired after practice in watching the effect made upon the movements of the spot of light.

In capacity tests the standard of comparison rarely exceeds one microfarad, and is frequently made in boxes of one-third of a microfarad, or about equal to one mile of cable. With a

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few hundred miles of cable on, therefore, there is a great disparity between the amounts of capacity to be compared, and the measurement by simple comparison of discharge is open to objection. With momentary currents through the galvanometer, the simple ratio of the multiplying power of the shunt is not strictly true, because the current through the galvanometer is choked by the self-induction of the coils, while the current through the shunt passes with nothing more than the ohmic resistance of the shunt coils to oppose it, these, like all resistance coils, being wound non-inductively. On the other hand, without a shunt to reduce the discharge throw of the cable within comparable limits, the two readings are inconveniently far apart on the scale, and any slight errors in observation affect the result considerably. The method of Thomson, by which the two discharges are mixed and neutralised, leaving no current, when balanced, to pass through the galvanometer, is greatly in favour, both on account of its accurateness in measuring widely differing capacities and ease of manipulation. Either a Lambert or Saunders key is usually supplied to stations and ships for this test, by means of which the consecutive operations of charging separately, discharging together, and connecting to the galvanometer are performed, while the resistance on one side is simply adjusted by hand till balance is attained.

In all electrical tests it is well to notice what degree of accuracy can be attained. This depends partly upon the observations, whether of deflection or zero balancing methods, and partly upon the arithmetical calculations, which have to be made to arrive at the final result. In bridge tests it should be observed what are the limits between which balance can be maintained, and then the arithmetical calculation gone through again with the object of seeing how much the final result is altered by an error in observation of the amount determined by the above limits. Frequently this can be seen, as regards the calculation, by simple inspection of the algebraical form of the formula by which the test is worked out, some formula allowing much more margin for errors in observation than others. The smallness of the limits between which a balance can be maintained, or, in other words, the sensitiveness of an observation, depends more or less on the relation between the resistances of all the pieces of apparatus employed in the test, and also, as regards the galvanometer, upon the nature of the suspension, the number of turns of wire in the coil, and the position of the controlling magnet.

As reliability and dexterity are acquired in these ordinary tests, opportunities will more readily be found for assisting in the localisation tests when a fault or break occurs. There is no need, however, to wait for the appearance of a fault in the line in order to obtain practice. With a little sea water, a foot or two of cable core, and a bit of galvanised iron wire or plate, an artificial fault can be set up, which, together with some resistance coils, affords excellent practice in localisation tests. There is a distinct advantage in practising with faults of this kind, for with the artificial fault contained in a glass vessel, the process of deposition of chloride of copper upon the exposed part of the conductor, with the copper current, and the rate of evolution of gas with the zinc current can be closely watched, and a correct idea formed of what actually goes on at the fault in a submerged cable when under the action of testing currents. Moreover, the polarisation effect at the fault, that is, the electromotive force set up in opposition to the testing current, and in proportion to its strength, can be better observed in an artificial fault, because there is no cable discharge to prevent the observation of the false zero immediately after the circuit of the testing battery is broken. The rapid fall in the electromotive force of polarisation is thus more easily observed, and the importance better understood of working to a false zero, approximating as closely as possible to that value of this electro-motive force (or the current caused by it) which is in action during the application of the testing battery.

Faults of high resistance are sometimes localised by what are called fall of potential tests, the *fall* referring to the potential distributed along the cable when charged by a battery. In Mr. Clark's method the difference of potential between the ends of a resistance added to the line is measured at one end, while as nearly as possible at the same instant the potential at the other end is measured, that end being free, and, therefore, having the same potential as the fault. The potentials are measured either by an electrometer, a galvanometer and condenser, or a galvanometer and high resistance, and the results obtained at each end, compared by reference to some standard of electromotive force. This method, however, is not so well adapted for a small fault in a long cable, as the proper form of the curve of charge due to uniform leakage along the cable must be taken into account, and a somewhat lengthy correction applied. A successful departure from ordinary fall of potential tests has been devised by Messrs. Harold Ansell and Julian Young, depending on the electromotive force set up by the fault itself. When the fault is large, and its potential too low to obtain a satisfactory reading, a positive current can be put to line for a few minutes to seal it up and raise the potential, the test being independent of the actual resistance offered by the fault.

(To be continued.)

ELECTRICAL EXHIBITION AT THE CRYSTAL PALACE.

The visit of the Lord Mayor on Saturday last to the Electrical Exhibition at the Crystal Palace was the occasion of a considerable gathering, both of the exhibitors and of others interested in electric lighting. Almost all the strictly electrical exhibits were completed; but those of some of the upholstering and furnishing exhibitors, who always put in an appearance on these occasions, were still in a rather backward state. The machine-room is well worth a visit by every electrical engineer; and no mechanical engineer should lose such an excellent opportunity of inspecting, not only dynamos, but the engines which are used for driving them.

It is to be noticed that a particular type of engine has become very popular for both direct-driven and belt-driven dynamos. It is by no means a new pattern. We refer to an inverted double-acting engine, with a cast-iron standard, something like one-half of the standard of the old steam-hammer type, but instead of the second half massive wrought-iron pillars are provided. While these are excellently adapted for taking the longitudinal stress, they present the great advantage that the engine has a front and a back, and that the front is easily accessible. The old-fashioned table engine, in which four or more wrought-iron, or even cast-iron pillars, supported a casting which was dignified by the name of entablature, was thoroughly accessible, but the columns alone presented too little lateral stiffness. Excellent examples of this type are to be found in the Raworth engines, which are driving Brush machinery, the largest size giving 250 H.P. at 167 revolutions, and also in the large Davey Paxman engine driving the Kapp multipolar dynamo, to which we have already referred. This engine is triple expansion, the high-pressure cylinder being 12in. in diameter, the intermediate 18¾in., and the low-pressure 30in., with an 18in. stroke. The engine works very smoothly; but we fail to see any advantage in running at so slow a speed as 130 revolutions per minute.

The latest makers who have adopted this class is the well known firm of Easton and Anderson, who exhibit one of their Stoker's patent high-speed engines. This engine, now running at Messrs. Easton and Anderson's stand, No. 42, consists of two tandem compound engines, side by side, working on to a common crankshaft, with cranks opposite, and having a fly wheel between them. The engines are single-acting, the cylinders being 6in. diameter and 10½in. diameter high and low pressures respectively, by 8in. stroke. It will develop at 100lb. steam pressure about 60 I.H.P., with 450 revolutions per minute, non-condensing; but is constructed to work with more pressure if required; in fact, it is working with 120lb. at the Crystal Palace under a light load on a small "Whitehall" dynamo. The principal features of it are—carefully-studied arrangement of the steam distribution in the cylinders, whereby the maximum of economy is obtained, and the valves are so arranged that the cut-off can be varied by means of Turner-

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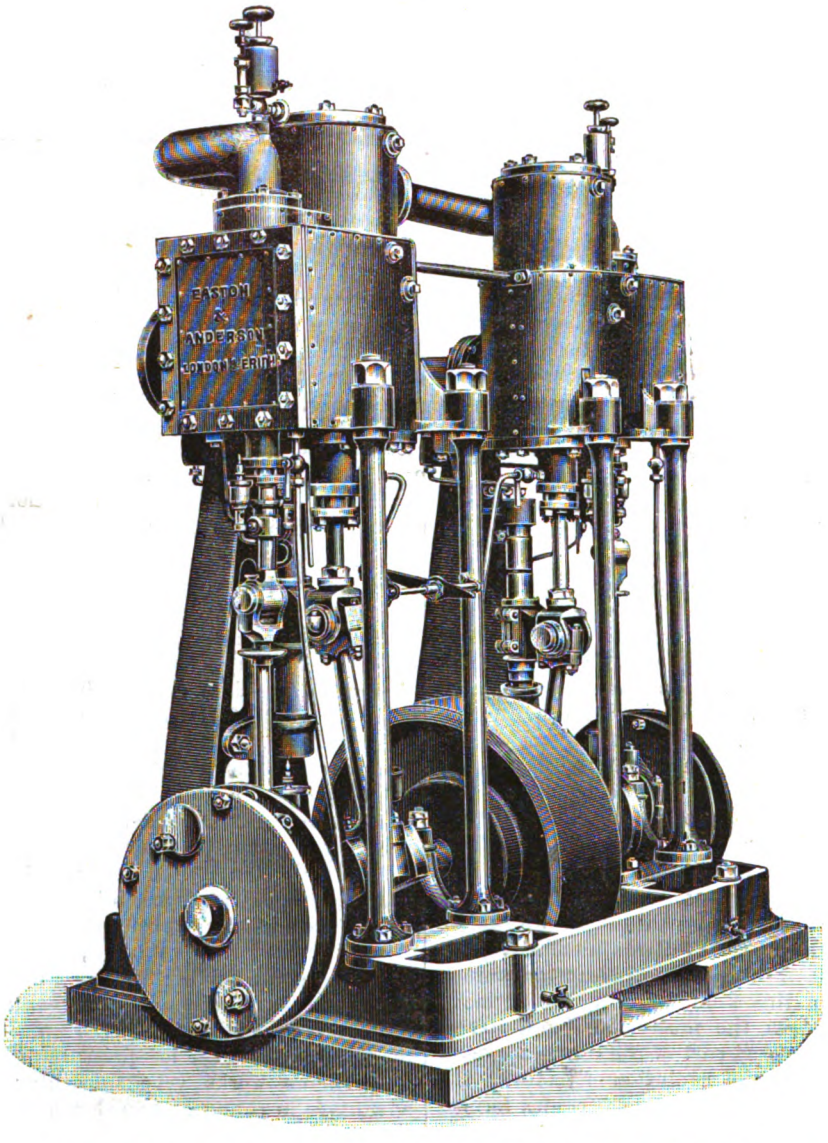
Hartnell or other crankshaft governors, as shown in the illustration, or it may be used with the ordinary eccentrics, and an ordinary governor such as the Pickering, with which it is now running at the Crystal Palace.

The other points to which special attention has been given are—the accessibility of all parts for ready inspection and removal; stiffness of the whole structure; lightness of the moving parts, whereby, together with the steam distribution, quiet running is assured; efficient lubrication of all parts, so that every bearing and surface can be efficiently oiled during the longest runs, without the necessity of stopping the engine. Noteworthy features in this engine are its high piston speed, and the use of pillar guides. These are not new; but we think might oftener be adopted with advantage. The old-fashioned slipper guide, with its planed surfaces, has been replaced by a cylindrical guide in several gas engines and steam engines, the surface being shaped while the cylinder is being bored; but adjustment for wear is rather troublesome. The pillar guides in this engine are lubricated by a sheet brass sleeve carried by the crosshead, and cut with many longitudinal slits. This dips into oil at every stroke. As running at the Crystal Palace, the engine is driving a dynamo by means of a belt, but it is equally well adapted for coupling direct on to a dynamo.



Stoker's Patent High-Speed Engine. (Made by Messrs. Easton & Anderson.)

The massive Siemens dynamo is erected, but does not look quite so large as it did when the pieces were lying about. Perhaps the most prominent machine in the room is the 130-unit Crompton dynamo, coupled to a Willans engine. This bears the card, "Sold to the Notting Hill Electric Supply Company," as if the secretary of that Company had happened to pass by the stand and made the purchase on the spot. The Crompton exhibit includes not only steam-engines, but also a good show of Crompton-Howell accumulators, and a very complete demonstration of the method of laying mains on the Crompton conduit system. Some yards of main have actually been laid in a concrete conduit, and a large grave has been dug in the space representing the roadway, to allow visitors to descend to the level of the conduit, and to inspect it through side holes which open into the grave. It may be noticed that almost every dynamo in the Exhibition is provided with gauze brushes; and we observed that the Taunton dynamos are provided with screw-feed brush-holders, allowing an adjustment to be made without slackening or tightening the nut holding the brush. An ingenious arrangement for preventing waste of the butt end of brushes has been invented by Mr. Dowsing, who has adapted the well-known candle "save-all" system. We hope on another occasion to make a still more careful examination of the dynamos; but up to the present we have failed to discover much that has not already been described in these columns.

Steam is supplied to the engines by a set of eight steel locomotive boilers, made by Davey Paxman. These are independently connected to a steel steam receiver, and the steam piping throughout the machine-room is very well arranged. A large number of gas engines are running at the south end

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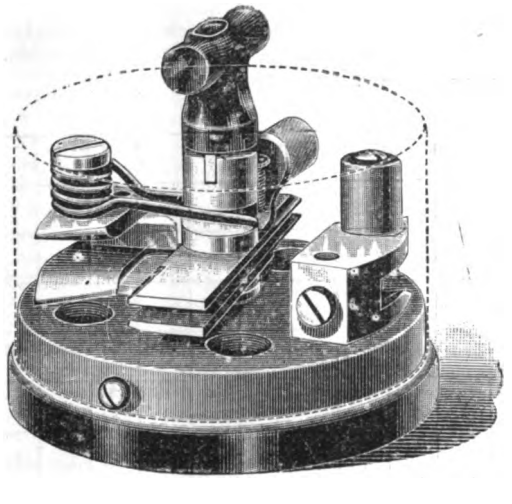
of the machine room; but there is either very little to be said about gas engines, or the attendants are singularly uncommunicative.

A large wire screen has been erected across the nave, at the north end of the Exhibition, on which a number of devices in glow-lamps (forming advertisements of the Edison Swan Company) are arranged and are switched in in succession during the evening.

The one department in which novelties are always to be found, but which is singularly destitute of originality, is that of artistic fittings. A very extensive display of these is to be found at the Crystal Palace; and all those who are intending to fit their houses with the electric light should certainly pay a visit to the numerous stalls and furnished rooms. We hesitate to criticise the art fittings, since they are only incidentally connected with electric lighting, and ought to be treated upon artistic grounds. We suppose that we are very hard to please; but we could find very little that was really satisfactory, except some good plain iron work at the stand of Messrs. Shirley and Co. This firm also shows some very good and simple examples of artistic iron work. There is one notable exception, of a single pendant with a set of appropriate brackets, which surpasses anything else in the Exhibition, and this we hope to illustrate on a future occasion.

The gallery of the south nave is fitted with a number of rooms, most of which are overloaded with decorations and ornaments. In those of Messrs. H. J. Cooper and Co. it is rather



difficult to find the electric fittings at all. These fittings consist of some good work of Messrs. Faraday and Son; but the use of electrically fitted candlesticks upon a dining-room table seems to be a confession of weakness, and reveals a sad want of imagination. Cupids, hung up like game by the heel, are considered by some to be a very artistic and novel means of suspending a glow lamp. Frank Giles has a room fitted with some very fine oak carving and another decorated in the French style; but these are lit almost entirely by imitation candles, with small flame-shaped glow-lamps. The method of lighting is, in our opinion, about as inartistic as it is possible to conceive. There is no doubt a difficulty in lighting a room decorated in the French style with anything but candelabra, and given candelabra it requires a little courage to put anything else than a candle in them. An utterly impossible room is shown by Messrs. Allen and Mannock. The ceiling is covered with quilted satin, and the whole is very like an elaborate *bon bon* box turned outside in. In the south nave there are several stands of fittings, most of which are merely hung up side by side as in a show-room, without any attempt to represent a habitable apartment.

No article on an Electrical Exhibition would be complete without some blocks taken out of price lists and catalogues. We therefore illustrate a switch made by Messrs. Dorman and Smith, which is provided with Siemens patent carbon breaks. It will be seen that the switch itself consists of two metal plates, which pass between splayed contact jaws, making a firm spring contact. One of these jaws carries a carbon block, and another is mounted upon the working part of the switch. The mechanism is arranged so that contact is finally broken by the separation of these carbon blocks. Messrs. Dorman and Smith occupy the uncommon position of confining themselves to the sale of their own manufactures, and do not fill up their catalogue with engines, boilers, dynamos, and multifarious sundries of other makers.

The management of the Crystal Palace is to be congratulated upon the fine display of machinery apparatus and accessories, which are sure to attract many visitors; but they are fettered in an unfortunate manner by various contracts, which inconvenience both exhibitors and visitors in a way which they must often regret. No exhibitor can photograph his stall except by stealth, because of a photographic contract; the printing and publishing contractors look sharp after their pound of flesh, and it is a wonder that they do not insist on printing all the exhibitors' circulars. Of the refreshments and restaurant department it is only necessary to say that it is as bad as ever.

THE METRIC SYSTEM.

In the course of some interesting articles in the *Engineering Magazine* of New York, in which Mr. Coleman Sellers is trying to demonstrate "American Supremacy in Applied Mechanics," he makes the following observations on the use of the metric system in engineering.

The much-traduced metrology of England and America lends itself most happily to standard sizes that can be readily memorised and readily used. This does not come from any particular merit in the English inch, but in the non-use of a purely decimal division of a unit. The inch divided into fourths, eighths, sixteenths, thirty-seconds, and sixty-fourths by successive halvings, permits a graduation of sizes that can be memorised, making shop sizes to vary by a sixteenth of an inch up to one inch or two or three or a quarter of an inch above that size, presenting a memorisable series of sizes that is as natural as the divisions of music.

In countries using the metric system the millimetre is the unit of the machine shop, and an iron rod 1in. in diameter called 25 millimetres, even when it measures $25\frac{4}{10}$ exact, and drills used in the shop for advancing in size by a millimetre, from 4 millimetres to 25, will give more separate dimensions than are really needed. Economy in shop equipment is found in the use of only a limited number of progressive sizes, as each standard dimension requires many separate pieces in all the tools made to that size; even in a modern tool-room, counting all the taps, drills, reamers, gauges, boring tools, turning and planing tools for any one given size, there will be found from 70 to 140 separate and distinct tools to each size. The multiplication of sizes is attended with great cost in stock and on compensating gain.

In practice, the metric nations use the empirical graduations of shop sizes, advancing by two or three millimetres in a series that is not uniform but nearly approximates to the separate gradations in use in rolling the iron turned out by the English rolling-mills, which are scaled to the usual division of an inch, five-eighths, three-fourths, and so on.

The French centimetre may be divided as we divide the inch; but with the new divisions of the centimetre in halves, quarters, eighths and sixteenths, comes the destruction of the decimal system, which, in truth, is of less value when applied to measures and weight than it is in currency, and the intensity with which the British nation holds to its duodecimal system of money and the rapidity with which even the most ignorant use this seemingly complicated currency shows that there is not so much merit even in the decimal system of money to introduce it when a nation must be taught new habits of thought.

Long before the metric system was legalised in America, the present writer readily agreed to its adoption in a large department of the workshops he was then interested in, in order that in doing one particular kind of work which lent itself readily to the metric metrology, the experiment could be tried as to its superiority over that in common use; but with the result of

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satisfying himself that it was very far from meeting the exaggerated claims made for it by its advocates. The metric system is now legalised in America, and with this legalisation legislative action should end. Let those new branches of trade that are springing up, the new developments of art and science that can use the metric system to advantage, do so. The present condition of metrology with the English-speaking nations adhering to a non-decimal division of the inch with all Russia to back them in it, the time is not come, if it ever will, that this great population should be compelled by legal action to depart from standards and methods that have been accompanied by such surprising advance as has been shown in the nineteenth century. This is the more true when men willing to test the new metric system find it, after more than a quarter of a century's use, less advantageous than has been represented in some branches of applied mechanics. Those only are capable of judging of this matter who have become familiar with both systems to the extent of being able to think in either system of metrology as readily as some men can speak and write several languages.

There are cases in which the metric system can be used universally; in such cases let it be used; let it be taught in the schools, then through the survival of the fittest the truth will be reached. Chemists and electrical engineers should be free to use what is best; while those who are familiar with pounds and ounces should be free to buy and sell with the weights and measures most familiar to each.

ON THE LAW OF HYSTERESIS.*

BY CHAS. PROTEUS STEINMETZ.

In the number 137, of December 17, 1890, of the *Electrical Engineer* I published a short article under the title "Note on the Law of Hysteresis," where I showed that in a set of determinations of the loss of energy due to hysteresis by reversals of magnetism, for different magnetisations, made by Ewing, this loss of energy due to hysteresis can fairly well be expressed by the equation

$$H = \eta B^{1.6},$$

where H is the energy consumed by hysteresis during one magnetic cycle, in ergs per cubic centimetre, B the magnetisation in lines of magnetic force per square centimetre, and η † a numerical coefficient, in this case = ·002.

Considering that even the simple law of magnetism—that is, the dependence of the magnetisation B upon the magneto-motive force F (for instance, in ampere turns per centimetre length of the magnetic circuit)—has until now defied all attempts of mathematical formulation, it appeared a strange feature that the apparently much more intricate phenomenon of hysteresis, or rather of the consumption of energy by hysteresis, should yield to analytical formulation in such a simple way, to be directly proportional to the 1·6th power of the magnetisation. At the same time the coincidence of Ewing's tests with the curve of the 1·6th power was near enough to be considered as something more than a mere incident, but at least as a clue to a law of hysteresis, the more as this law held not only for low and medium magnetisation, but even for very high saturation, without showing any kink at that point where the magnetic characteristic goes over the bend or "knee," and thereby entirely changes its shape, nor any marked tendency of deviation of the extremest observed values from the calculated curve.

In Fig. 1 and Table I., I give from the article referred to, the calculated curve of hysteretic loss, as a drawn line, with Ewing's tests marked as crosses, and in dotted line the curve of magneto-motive force F, corresponding to the different magnetisations, as abscissæ.

In the Table I. :

F = the M.M.F. in absolute units,

B = the magnetisation in lines of magnetic force per square centimetre,

H_{obs} = the observed values, and

$H_{calc.}$ = the calculated values of hysteresis loss in ergs per cubic centimetre,

$H_{calc.} - H_{obs.}$ = the difference between, both in ergs and in percentages.

TABLE I.

F	B	$H_{obs.}$	$H_{calc.}$	$H_{calc.} - H_{obs.}$	$= \%$
1·50	1,974	410	375	+ 35	+8·5
1·95	3,830	1,160	1,082	+ 58	+5·0
2·56	5,950	2,190	2,190	--	—
3·01	7,180	2,940	2,956	- 16	- ·5
3·76	8,790	3,990	4,080	- 90	-2·3
4·96	10,590	5,560	5,510	+ 50	+ ·9
6·62	11,480	6,160	6,260	- 100	-1·7
7·04	11,960	6,590	6,690	- 100	-1·5
26·5	13,700	8,690	8,310	+ 380	+4·4
75·2	15,560	10,040	10,190	- 150	-1·5
				Av: ± 98 =	±2·6

To study more completely this phenomenon of hysteresis, and of the energy consumption caused thereby, I endeavoured to make a number of determinations with different magnet circuits and at different magnetisations.

To be enabled to carry out these experiments, I am highly obliged to Mr. Rudolph Eickemeyer, of Yonkers, N.Y., who, being greatly interested in the laws of the magnetic circuit, and having done considerable work himself in this branch of electrical science, not only put the large facilities of his well-known factory at my disposal, but also guided the experiments with his valuable advice. A part of the instruments used in the tests are of Mr. Eickemeyer's invention and covered by his patents.

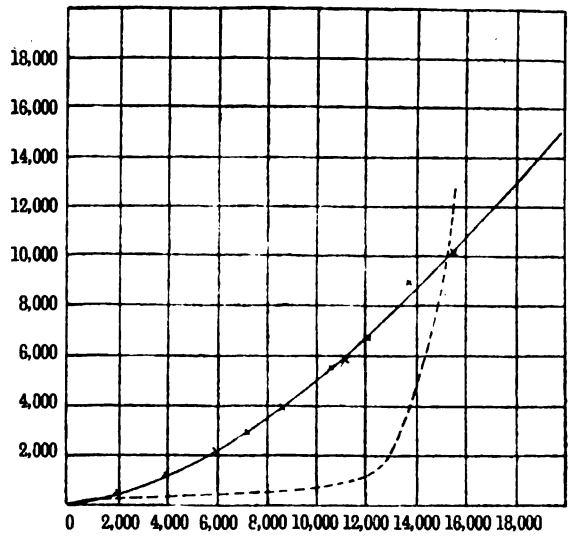

FIG. 1.

To be able to deal, not only with the small amounts of energy which the reversal of magnetism in a tiny bit of iron wire sends through the ballistic galvanometer, but to reduce the determinations to readings of considerable power-values, and where a much greater exactness can be reached, and at the same time to determine the dependence of the hysteretic loss of energy upon the velocity of the magnetic cycles, I decided to use alternating currents, at least as far as this could be done, whereby the determinations of the energy consumed by hysteresis is reduced to a simultaneous wattmeter, voltmeter, ammeter, and speed reading.

At the same time this electro-dynamometer method has the advantage that the magnetic cycle is completed in a steady, continuous motion, while in the ballistic method the magnetic cycle is completed by sudden changes in the magnetisation, which jumps from point to point, to enable the production of the induced current. This feature introduces an error into the ballistic method; for if a magnetic cycle is gone through by sudden changes, a larger amount of energy may be consumed than if the magnetisation varies steadily in harmonic vibration.

Suppose, around a magnetic circuit, an alternating current of n periods per second is sent in c convolutions.

* Abstract of a Paper read before the American Institute of Electrical Engineers, New York, January 19, 1892.

† If any quantity has a right to be called "magnetic resistance," it is this coefficient η; for η is the *coefficient of conversion of magnetic energy into heat*, while as "electric resistance" we define the *coefficient of conversion of electric energy into heat*.

The term generally denoted "magnetic resistance"—that is, the inverse value of magnetic susceptibility—does not deserve this name at all, but is more properly called "reluctance."

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Let C = the effective strength of the current,

E = the effective E.M.F. induced in the circuit by self-induction, after subtracting the E.M.F.s induced by the self-induction of the instruments,

W = the energy consumed in the circuit, after subtracting the energy consumed by the electric resistance,

Then, l being the length and s the cross-section of the magnetic circuit, all in centimetres, amperes, volts, watts, &c.,

Let $\mathbf{B}$ = the maximum magnetisation in lines of magnetic force per square centimetre,

H = the loss of energy by hysteresis per cycle and cubic centimetre; it is

$$W = l\,s\,n\,H \times 10^{-7};$$

hence

$$H = \frac{W}{l\,s\,n} \times 10^{-4},$$

the hysteretic loss of energy, and

$$E = \sqrt{2}\pi\,s\,\mathbf{B}\,n\,c \times 10^{-8}.$$

hence

$$\mathbf{B} = \frac{E \times 10^{+8}}{\sqrt{2}\pi s n c} \quad (*),$$

the maximum magnetism.

For higher frequencies, 80 to 200 periods per second, the alternating current was derived from a 1 H.P. 50-volt Westinghouse dynamo. This was driven by a 3 H.P. Eickemeyer continuous-current motor. By varying the excitation of the motor field, and varying the E.M.F. supplied to the motor, the speed and therefore the frequency of the alternating current could be varied in wide limits. At the same time, supplied with constant E.M.F., and like all the Eickemeyer motors of unusually small armature reaction, this electromotor kept almost absolutely constant speed under varying load, the more as it never ran with full load.

For low frequencies, this bipolar continuous-current motor was used as a bipolar alternating dynamo, as shown in a patent of Mr. Stephen D. Field. On the continuous-current commutator two sliding rings were mounted and connected with opposite commutator bars. In the ordinary continuous-current brushes a continuous current was sent in, which set the machine in motion as an electromotor, while from the sliding rings by two separate brushes alternating currents were taken off. By varying the E.M.F. supplied to the motor, the E.M.F. of the alternating current was varied, while a variation of the motor field gave the variations of the frequency. The curve of E.M.F. was very nearly a sine-wave, the ratio of maximum E.M.F. to effective E.M.F. found = 1·415, while the sine-wave requires 1·414—that is, exactly the same.

To determine whether the change of the shape of the alternating current by varying load and varying excitation had any influence upon the readings, the variations of the alternating E.M.F. were produced:—

1. By varying the excitation of the field of the Westinghouse dynamo.

2. By running the Westinghouse dynamo fully excited, feeding the secondaries of a bank of converters, feeding from the fine wire coils of these converters the fine wire coils of another bank of converters, and taking current off from the secondaries of these converters, connected from one to six in series.

3. By changing the E.M.F. by means of a Westinghouse converter of variable ratio of transformation.

4. By loading the dynamo when small currents were used for the tests.

But after having found that all these different ways of varying the alternating E.M.F. gave no perceptible difference whatever in the readings, I afterwards used the most convenient way to vary the excitation of the dynamo field, and, where higher E.M.F.'s were needed, to increase the E.M.F. by an interchangeable converter, which gave the ratio:—1: 1, 2, 3, 4, 5.

For the determination of the frequency, a direct-reading speed indicator (horizontal ball governor, acting upon a spring) was used, which was carefully calibrated.

For the electric readings, instruments of the electro-dynamometer type were used, zero reading—that is, the movable coil was carried back by the torsion of a steel spring to zero position.

* This formula holds rigidly only for the sine-wave; but as shown in the following, the currents used in the tests were at least very near sine-waves. Besides, a deviation from the sine shape would not alter the results at all, but only slightly change the coefficient η.

These instruments were specially built for alternating currents, with very low self-induction and low internal resistance, using bifilar German silver wire as additional resistance.

In the ammeter the range of readings was from 3 to 40 ampers the internal resistance = ·011 ω.

The normal inductance (that is, E.M.F. of self-induction induced by one ampere alternating current, flowing through the instrument with a frequency of 100 complete periods per second: = ·045 ω.

In the voltmeter the range of readings was from ·5 volts upwards, but to avoid the necessity of corrections for self-induction, sufficient additional resistance was used to decrease the correction under 1 per cent., and then the lowest readings were from 3 to 6 volts.

The internal resistance of the voltmeter is = 2·5 ω, its normal inductance = 4·12 ω.

In the wattmeter the resistance of the coarse-wire coil (fixed coil) was = ·026 ω, its normal inductance ·073 ω.

The internal resistance of the fine-wire coil was = 25 ω, its normal inductance = ·33 ω.

In most of the readings sufficient additional resistance was used to make the correction for self-induction of the fine-wire coil negligible. Only in a few readings where it exceeded 1 per cent. it was taken in account.

For small currents an Eickemeyer ammeter was used, which, while reading from ·7 to 3 amperes, though built originally for continuous currents, had already been used by me for alternating currents, and had been checked for its constancy of readings several times, and always found to give no perceptible difference in its readings for continuous currents and for alternating currents up to over 200 complete periods per second, the highest frequency I could reach.

Its internal resistance is = 1·1 ω, its normal inductance = 2·03 ω.

Several sets of readings for different frequencies were taken on an old Westinghouse voltmeter converter. The fine-wire coil and one of the 50-volt coils were left open. Into the other coarse-wire coil an alternating current was sent, in series to ammeter and coarse-wire coil of wattmeter, while the voltmeter and the fine-wire coil of the wattmeter were connected in shunt around the whole circuit.

Hence a correction had to be applied for the self-induction of ammeter and coarse-wire coil of the wattmeter and for the resistance of the circuit. Only in very few readings this correction amounted to somewhat more than 10 per cent. Generally it was much smaller.

The instruments were calibrated several times, and their constants found to remain constant.

The speed indicator was calibrated carefully, and its corrections added.

Each reading consisted of an ammeter reading, a voltmeter reading, a wattmeter reading, and a speed reading.

Before and after each set of readings the zero positions of the instruments were determined, and only those sets of readings used where the zero position had remained constant.

Before and after each set of alternating-current readings a continuous current was sent into the circuit and a few readings for different currents taken. Voltmeter and ammeter readings combined gave the resistance of the circuit, and both combined with the wattmeter reading gave a check for the instruments, here being watts = volts × amperes. Only those sets were used again where an entire agreement was found, and with the alternating current first readings with small currents taken, then with large currents, and then again with small currents taken, so that I believe every possible care was exercised to avoid any errors in the tests.

As before said, the first sets of tests were made on the magnetic circuit of a small Westinghouse converter.

The constants of this converter, so far as they are of interest here, are:

Mean length of magnetic circuit, 21cm.

Mean cross-section of magnetic circuit = 43·67cm.^{2}

Hence volume of iron, = 917cm.^{3}

Resistance of secondary coil, = ·2 ω.

Further sets of readings were taken on a magnetic circuit, built up of very thin sheets of iron, alternately 8in. × 1in. and 3in. × 1in., in rectangular shape, very carefully insulated against eddy currents with layers of thin paper between the sheets. On the two long sides two coils of each 50 turns, very coarse wire (3 No. 10 in parallel), were wound and connected in series, thereby giving n = 100 turns of an internal resistance of ·048 ω.

Here the mean length of the magnetic circuit was l = 41cm.

The cross-section, s = 3 784cm.^{2}

The circuit consisted of 58 layers of sheet-iron of the thickness s = ·02577 (*) and the width w = 2·579.

The whole volume of iron was = 155cm.^{3}

The sheet-iron pieces were first freed from scales by dipping into dilute sulphuric acid.

* Calculated from the weight.

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In one set of tests an open magnetic circuit was used, by leaving the short end pieces (3in. × 1in.) off, and using two piles each of 66 pieces (8in. × 1in.) of the same iron, the same pieces as used in the former closed circuit tests.

In these readings, for the determination of the hysteretic loss, only voltmeter and wattmeter, but no ammeter, were used, and the susceptibility curve determined separately by voltmeter and ammeter.

The calculation of the readings was done in the following way:

After applying the corrections for self-induction of instruments, resistance and speed, the readings were reduced to lines of magnetic force per square centimetre **B** and consumption of energy by hysteresis per magnetic cycle H, in ergs.

Then the results were plotted on cross-section paper, and if any value was found to be very much out of the curve connecting the other values, it was stricken out as evidently erroneous, not considering it worth while to determine whether it was a wrong reading of any one of the instruments or a mistake in the calculation.

Then from the other values of **B** and H, under the supposition that H were proportional to any power x of **B**,

$$H = \eta \mathbf{B}^x$$

this exponent x was determined.

This value x will be seen always to be so near to 1·6 that 1·6 can be considered at least as first approximation to x.

Then, under the assumption

$$x = 1{\cdot}6$$

hence

$$H = \eta \mathbf{B}^{1{\cdot}6}$$

the coefficient η was calculated, and now the equation

$$H = \eta \mathbf{B}^{1{\cdot}6}$$

plotted in a curve, as given in the figures, and the observed values of H drawn in and marked.

From the curve were taken the calculated values of H, corresponding to the observed values of B, the difference $H_{calc} - H_{obs}$ determined, and expressed in per cents of H_{calc}.

These values are given in the tables and shown in the curves.

I.—Magnetic Circuit of the Westinghouse Converter.

In the following Table the results are given of many observations taken at different frequencies, n, and induction densities **B**. In this Table the numbers in the third column denote the power of **B** which is most nearly proportional to the hysteresis loss H, and the next column gives the corresponding coefficient η. The last

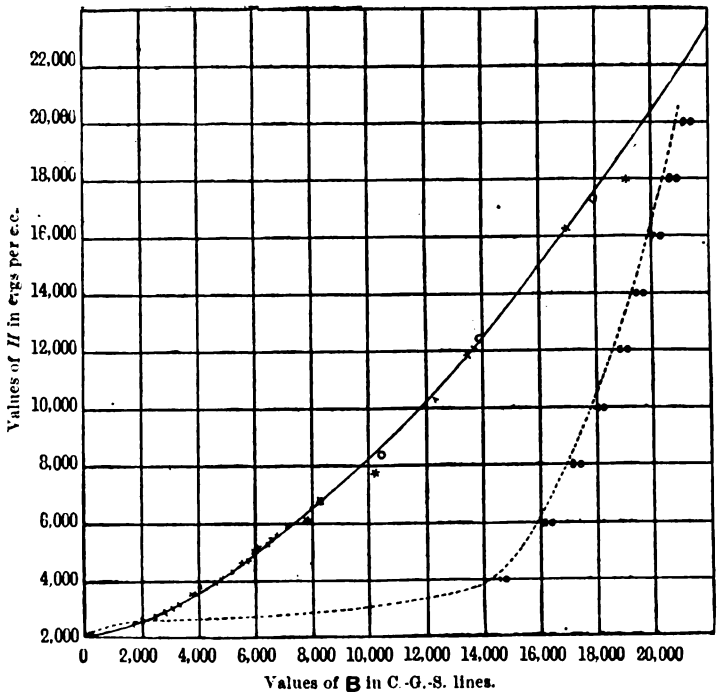

Fig. 2.

column indicates the agreement of the observed and calculated values, as it is the average percentage difference between them.

1	...	$n=28$	...	4 readings:	$x=1{\cdot}6111$	...	$\eta=\cdot002410$	... 2·3 %
2	...	36	...	5 „	1·6476	...	·02315	... 4·4 „
3	...	137	...	10 „	1·5887	...	·002438	... 2·0 „
4	...	205	...	18 „	1·6012	...	·002434	... 2·7 „

Therefrom we derive the average, by giving to each value as weight the number of readings, where it is based upon:

$$x = 1{\cdot}60513 \sim 1{\cdot}6$$

$$\eta = \cdot0024164.$$

Hence,

$$H = \cdot0024164\, \mathbf{B}^{1{\cdot}6}.$$

This curve is used for calculating the values given as H_{calc}, and is plotted in Fig. 2 in drawn line.

The observed values of H are drawn in Fig. 2:—

1. For $n=28$ with the mark o
2. „ 36 „ „ *
3. „ 137 „ „ v
4. „ 205 „ „ +

The magnetic characteristic is drawn in dotted lines, and the numbers on it denote the values of the magneto-motive force F in ampere turns per centimetre length.

From this curve of hysteretic loss

$$H = \cdot0024164\, \mathbf{B}^{1{\cdot}6}$$

we derive the values:

Table II. (6.)

B.	H.	B.	H.
1,000	152	13,000	9,230
2,000	462	14,000	10,400
3,000	884	15,000	11,610
4,000	1,400	16,000	12,880
5,000	2,000	17,000	14,180
6,000	2,680	18,000	15,550
7,000	3,430	19,000	16,970
8,000	4,240	20,000	18,400
9,000	5,130	25,000	26,290
10,000	6,070	30,000	35,210
11,000	7,070	35,000	45,060
12,000	8,130	40,000	55,800

II.—Magnetic Circuit Built up of Well Insulated Layers of Very Thin Sheet-Iron.

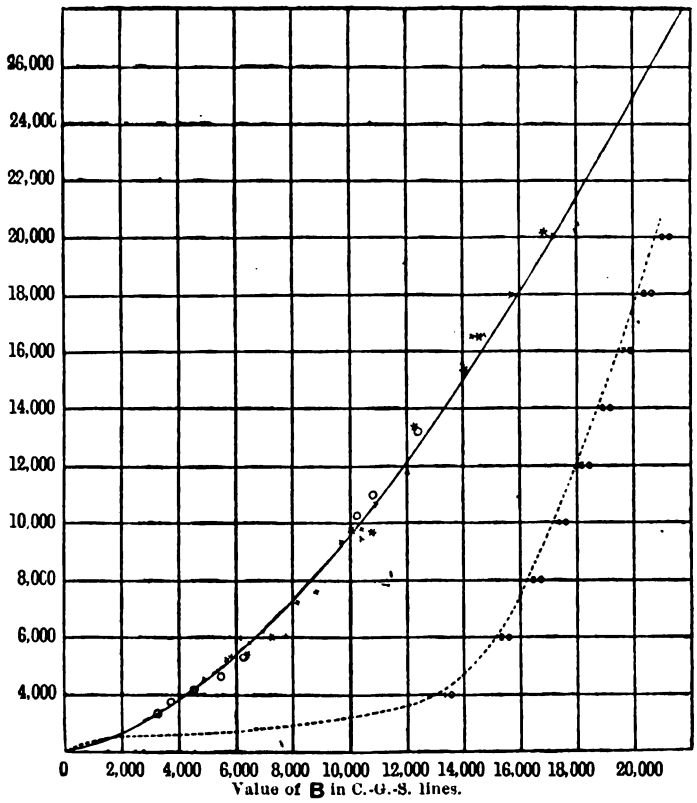

Fig. 3.

From four sets of readings we get the results:—

Closed Magnetic Circuit.

$n=$ 85	9 readings:	$x=1{\cdot}6041$	$\eta=\cdot00285$	...	4·4 %
138	14 „	1·6044	·00335	...	2·8 %
205	9 „	1·6970	·00373	...	3·7 %

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Open Magnetic Circuit.

$n=138$ 8 readings: $x=1{\cdot}6040$ $\eta={\cdot}00393$ 3·4 per cent.

Herefrom it seems that the consumption of energy by hysteresis per magnetic cycle increases with increasing frequency—that is, with increasing velocity of the magnetic change.

The three values of three coefficients of hysteresis for closed circuit in their dependence upon the frequency n, can be expressed by the *empirical* formula:

$$\eta=({\cdot}0017+{\cdot}000016\,n-{\cdot}00000003\,n^2).$$

To compare the values of hysteretic loss for different frequencies, in Fig. 3 the curve of hysteretic loss for $n=100$ complete periods per second is plotted, giving:

$$\eta_{100}={\cdot}003;$$

hence,

$$H={\cdot}003\,\mathsf{B}^{1{\cdot}6},$$

and the observed values of H are not directly drawn in, but the observed values of H multiplied with the factor:

$$\frac{\eta_{100}}{\eta\,\text{obs.}},$$

to compare the different frequencies with each other.

These values are plotted for:

$n=$ 85 with the mark Y
138 ,, ,, + } Closed magnetic circuit.
205 ,, ,, *
$n=138$ with the mark O; Open magnetic circuit.

From this curve of hysteretic loss,

$$H={\cdot}003\,\mathsf{B}^{1{\cdot}6},$$

we derive the values, for the frequency of $n=100$ complete periods per second.

TABLE III.

B.	H.	B.	H.
1,000	190	13,000	11,460
2,000	570	14,000	12,900
3,000	1,100	15,000	14,430
4,000	1,740	16,000	15,990
5,000	2,490	17,000	17,610
6,000	3,330	18,000	19,290
7,000	4,260	19,000	21,060
8,000	5,280	20,000	22,830
9,000	6,360	25,000	32,640
10,000	7,530	30,000	43,680
11,000	8,790	35,000	55,950
12,000	10,080	40,000	69,270

Especially noteworthy is the last set of readings, on open magnetic circuit, in so far as it proves the fallacy of the general opinion that the hysteretic loss of energy in the iron is smaller in the open magnetic circuit than in the closed circuit.

For the coefficient of hysteresis observed on open magnetic circuit

$$\eta={\cdot}00393$$

is even greater than that for closed magnetic circuit,

$$\eta={\cdot}00335.$$

But this discrepancy is easily explained by the fact that in the closed magnetic circuit the magnetisation is nearly uniform throughout the whole iron. But in the open magnetic circuit the magnetic field intensity differs considerably from point to point, being a maximum in the middle of the magnetising coils, a minimum at the ends of the iron sheets. Now, the values of B given in the table are the average values of the magnetisation, and the values H the average values of hysteretic loss. But the average value of the 1·6th powers of different quantities B is larger than the 1·6th power of the average value of B.

For instance, in a cubic cm. of iron magnetised to $\mathsf{B}=12{,}000$ is $H=10{,}080$; in a cubic cm. of iron magnetised to $\mathsf{B}=6{,}000$ is $H=3{,}330$; hence of these 2 cubic centimetres the average magnetisation is

$$\mathsf{B}=9{,}000,\text{ and the average } H=6{,}705\text{ ergs},$$

but to $\mathsf{B}=9{,}000$ corresponds $H=6{,}360$ ergs; that is, about 5 per cent. less, and the difference becomes still greater, if the values B differ still more.

Taking this into account, it seems that the loss of energy due to hysteresis depends only upon the intensity of magnetisation, and, perhaps, upon the frequency, but is independent of open or closed magnetic circuit, as is to be expected.

(To be continued.)

DEVELOPMENTS OF ELECTRICAL DISTRIBUTION.*

BY PROF. GEORGE FORBES, F.R.S.

On commencing his third lecture Prof. Forbes alluded to the work and experiments of Mr. Nikola Tesla. The "practical man," said Prof. Forbes, had asked in a technical journal what it would all lead to. His advice to the "practical man" was to leave Mr. Nikola Tesla's experiments alone; the so-called "practical man" could hardly appreciate the value of such work. He had hoped the time was now passed for those who had formerly done so to arrogate to themselves the title of "practical man." Such an arrogation showed great self-sufficiency, for the title was the highest possible; even our greatest men did not speak of themselves as "practical men." As a rule the title was assumed by those who could use their hands, but not their heads.

To engineers and natural philosophers Mr. Nikola Tesla's work was full of promise. The engineer saw great difficulties which had been in his way completely explained and partially removed. We now saw our way to producing a most pleasing light by means almost in a practical shape. The natural philosopher had had explained to him a vast number of experiments which puzzled him. Mr. Nikola Tesla triumphed as the natural philosopher to-day, to-morrow he would triumph as the engineer. To the natural philosopher the puzzling alteration in the capacity of the air condenser was now made clear. During the Lauffen-Frankfort transmission experiments a curious light was given off by the wires, and they were at a loss to account for it or to cure it. Mr. Tesla had given us the explanation and the cure. The value of oil as an insulator was indeed known before, but we had not realised its enormous importance.

Returning for a moment to the question of mains, the Siemens type of cable was, Prof. Forbes remarked, a good one in many respects. For feeders it was admirable, but, owing to the necessity for a special junction-box wherever the main was tapped, its cost was considerable when used as a distributing main.

Coming next to the question of Power, as apart from Light, Prof. Forbes said the subject could be divided into two totally different headings, viz., Transmission and Distribution. For instance, in the electrical utilisation of the Falls of Niagara, about which there had been much talk, the great problem was one of *transmission*. The *distribution* of the transmitted power through, say, the town of Buffalo 30 miles distant, was not of such enormous importance. At Clerkenwell, on the other hand, where there were a large number of small motors at work, the question of *distribution* became paramount. No place could be more suitable than Clerkenwell for putting down a large power station.

Whenever we were transmitting power to great distances high pressures became imperative, whatever system we employed; but an engineer never used a higher pressure than was absolutely necessary. In 1881 Sir William Thomson laid down his well-known general rule as to the most economical conductor to be used in any given case. This law was to the effect that the interest on the capital invested in copper should be equal to the cost of the energy wasted in it. In March, 1886, Prof. Ayrton read a paper before the Institution of Electrical Engineers, in which he endeavoured to show that Sir William Thomson's solution of the most economical section to give a conductor was quite inapplicable in a variety of cases connected with the electric transmission of power. Prof. Ayrton urged that, if a given amount of power had to be furnished at the end of a line with a given difference of potential at the dynamo terminals, the greatest economy was obtained not by keeping the current-density constant, but by making it diminish as the length of line became greater. As a matter of fact, all that Prof. Ayrton's mathematics went to show was that the further the distance the greater the cost of copper, and therefore the greater the cost of the energy. This was the whole secret of the mare's nest that Prof. Ayrton thought he had found in Sir William Thomson's argument. The only real practical way of applying the law was to gradually arrive at the most economical conductor by working out the problem for different current-densities.

In the transmission of powers to great distances were we to use continuous or alternating currents? Two years ago, if this question had been asked, nine-tenths of us would have answered that nothing was available except the continuous system. Indeed, the engineers who advised the Niagara Syndicate were on the verge of passing a resolution to the effect that alternating currents were out of the question. He did not desire, however, to under-value the continuous current system. MM. Thury, at Geneva, had erected both at Genoa and Geneva three continuous-current 2,000-volt generators, coupled in series. The difficulties of insulation connected with a physical junction with the source of power had been overcome by the use of Raffard couplings.

Looking at the numerous schemes in progress for providing

* Abstract of Cantor Lecture II., 3, delivered before the Society of Arts February 8, 1892.

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London with electric railways, it was worth while to consider the use of alternate currents in this connection. In tubular railways, such as proposed, the conductor expenses were solely in the conductor itself, the cost of erecting being in this case small, so that if alternate currents of high pressure were employed we had the total possible gain. Consequently, the adoption of alternate currents was not out of the question.

If we used ordinary continuous-current motors on alternating circuits the field-magnet must be laminated, and the frequency must be low. It was quite possible that if the use of alternate currents on a railway were decided upon at the present moment, low frequencies, and, suitably modified, continuous-current motors would be the best to recommend, owing to the high initial torque of such motors; although, such was the rate of progress, in a few months the aspect of affairs might possibly be quite different.

A type of motor which had attracted much attention was the synchronising alternate-current motor. It was simply the generator worked as a receiver. The synchronising motor had greatly puzzled the "practical man," to whom it was a mystery why some kept well in step and why some did not. A complete explanation was given by Dr. Hopkinson in a Lecture delivered before the Institution of Civil Engineers in 1883. But the drift of his arguments was somewhat misunderstood, and people set to work to put as much iron in the armature as was possible. The astonishment was, therefore, great when Mr. Mordey read his Paper, in which he showed that his alternator with no iron in the armature at all, and very little self-induction, worked as a motor most admirably. The puzzle was complete when comparison was made between Siemens or Ferranti machines and those of Mr. Mordey. The reason for the difference in the behaviour of those machines was simply that the power which was given to an alternating motor pulsated, so that momentum was required to get over dead centres. Now, the Mordey alternator had enormous momentum, owing to the fact that its heavy field-magnets revolved, and the Ferranti alternator only required a heavy flywheel to make it run as well as its rival.

In connection with the Niagara scheme he had recommended synchronising alternate-current machines, the Mordey being specially mentioned. It was proposed to transmit at 10,000 volts, and to transform down to 2,000 volts, and distribute to large synchronising motors in factories. For smaller motors it was proposed to couple synchronising machines to continuous-current dynamos and distribute to the usual type of continuous-current motors.

If we placed two dynamos on the same shaft at one end of the line, and used two similarly situated motors at the far end, and arranged matters so that one dynamo gave the maximum current, while the other gave the minimum, we had an arrangement exactly analogous to that adopted in locomotives, and one which contained the elements of the "rotating phase-system.

Prof. Forbes then explained the principle of the "rotating phase" system by aid of a diagram. There was not the slightest doubt that it was a most effective method of transmitting and distributing power. In addition to the elasticity of the ordinary alternate-current system, we had the enormous advantage that the motors had considerable torque on starting. A small 1 H.P. "rotating phase" motor had been tested by him with the following results:—Current was taken from the mains of the Westminster Company to a continuous-current motor driving an alternator which supplied current to the "rotating phase" motor, which drove a continuous-current dynamo feeding a bank of lamps. The "rotating phase" motor ran at 1,380 revolutions. On starting there was a pull of 40lb. on the 5in. pulley, which at top speed would mean 4 H.P.

TELEGRAPHIC AND TELEPHONIC COAST COMMUNICATION.

At the annual meeting of the Chamber of Shipping of the United Kingdom, held on Wednesday, Mr. Wm. Millburn, jun., the newly-elected President for the year, referred in his opening address to the question of telegraphic communication with lighthouses, lightships, and coastguard stations. He said the carrying out of such a proposal was of national importance, and would be a step forward in the interest of humanity, and as such was entitled to and would doubtless receive the fullest sympathy and support from shipowners. It was a scheme, however, which unfortunately was not to be carried out so easily as it looked. The physical difficulties were greater than at first sight appeared. Many of the lighthouses were situated on a ledge of rocks, and between them and the mainland the bottom was of the same description, with the sea at times breaking heavily upon it, so that no cable could stand for any length of time; and this would probably mean that these rocks would have to be tunnelled, and the cables carried by that means. Again, in the case of lightships, the danger to the cable by vessels anchoring and breaking or damaging it, would have to be guarded against, so that the cost must necessarily be a very serious one; and in dealing with the matter, shipowners would have to be careful that this cost should not be added to their already heavy burdens.

Col. Hill, M.P. (on behalf of the Cardiff Shipowners' Association), moved, "That, in the opinion of this Chamber, it is needful, for the preservation of life, that the lighthouses, lightships, and coastguard stations should be placed in telegraphic communication with each other and the general telegraphic system of the country where practicable." He said he was very pleased to move the resolution, because he had taken a great deal of interest in this important question, in his position as President of the Associated Chambers of Commerce. There was an immense amount of shipping round our coasts, and it was their duty as shipowners to do all in their power to look after the safety of the crews who navigated their ships. The British coasts were well-lighted and well-buoyed; but they were subject to fogs, and accidents sometimes occurred in clear weather as well as in thick. If they wanted to save life and property time was the very essence of success. If a ship got ashore it was of the utmost importance that communication with land should be made with as little delay as possible, so that the necessary life-saving apparatus might be forthcoming. He referred to wrecks, some recent and others which had occurred years ago, where the crews and passengers would of a certainty have been rescued if there had been telegraphic communication between lightships and lighthouses and the land. The question was becoming one of great public interest. It was being taken up by the press. In consequence of the numerous interests involved—the Board of Admiralty, the Post Office, and other departments—the Associated Chambers of Commerce some time ago asked the Prime Minister to receive a deputation on the subject. The Premier, however, thought it was a matter which concerned the Board of Trade. They went to the Board of Trade, and met with a very sympathetic reception from Sir Michael Hicks-Beach, who, however, said that although some experiments for saving life by telegraphic communication with the shore had been only moderately successful, and that further experiments should be made, the Board of Trade could not pay the expense. The Mercantile Marine had funds, and if those who had charge of that fund were willing to spend some of it in these experiments, Sir Michael was quite agreed that it should be done. He (Colonel Hill) was sorry to say the Council of the Mercantile Marine had not seen their way to an expenditure of their funds on the proposed experiments. He had no doubt that public opinion would eventually insist upon the expenses being borne by the National Exchequer. It was unfair that the shipping interest should be taxed with the whole cost of saving life round the coasts. He might mention that the Associated Chambers of Commerce had memorialised Lord Salisbury again, with the result that his lordship had expressed the intention of applying for the appointment of a Select Committee at an early date to investigate the matter. He (Col. Hill) did not see why we should be behind other nations in matters of this kind. He hoped the Chamber of Shipping would take the most active steps in pushing forward this matter.

Mr. John Williamson thought there ought to be no difficulty with regard to lighthouses and coastguard stations; but there were difficulties with regard to lightships, especially when the wires had to pass over rocks. Experiments had been tried on one or two occasions at the Fastnet, but owing to the continuous breaking of the waves no communication could be maintained. Similar difficulties had been experienced in other places. But, after all, there was no reason why a Parliamentary Committee should not be appointed to inquire thoroughly into the matter.

Colonel Hill consented to add the words "or telephonic communication" to his resolution, and it was carried unanimously.

At the annual banquet the same evening, at the Hotel Métropole, Sir Michael Hicks-Beach, in the course of his speech, in answer to the toast of "Her Majesty's Ministers," made the following remarks with regard to coast communication:—

"There is one subject on which I wish to say a few words to you to-night, because I understand it forms an important part in your deliberations to-day. It is the proposal for establishing electrical communication between lighthouses and lightships on our coasts and our telegraph stations inland. It seems to me that in almost all matters connected with shipping there is a tendency to exaggeration. I think there is a little tendency to exaggeration on the part of not a few who have written and spoken on this subject. In the first place, I think it is absurd to suggest that such communication could be established with all the lighthouses and lightships round our coasts for the sum of £100,000, or anything like it. Perhaps I may say that I have taken some steps to endeavour to ascertain the fact by furnishing the Post Office authorities with a statement of the distances between existing lighthouses and lightships and the nearest telegraph stations, and asking them to give

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an estimate of the probable cost of supplying communication. Secondly, some persons have suggested that such communication would be valuable in case of war for the defence of our coasts. My right hon. friend, the Secretary to the Admiralty, could speak on that subject with greater authority than I can, but I think he will support what I am going to say. If the Eddystone lighthouse, for instance, were to give warning to Plymouth of the approach of a French cruiser in the unhappy event of war between this country and France, that French cruiser, looking to the history of past wars, would be justified in blowing the lighthouse out of existence. That must be a material point in the consideration of this question. Thirdly, it has been suggested- or, perhaps, it is in theminds of some persons—that our lighthouse-keepers and our lightship-keepers might be utilised to perform the work which is now performed by Lloyd's signal stations for commercial purposes. I am glad you do not support that suggestion, because the lighthouse authorities are unanimously of opinion that the keepers have quite enough to do at present in securing the efficiency of their lights and fog-signals, and that it would be impossible to impose upon them any additional duties of this kind. We must look at this matter solely, I would venture to say, with regard to the saving of life in case of wrecks, and we must dismiss from our minds the idea that if every lightship and lighthouse were connected by telegraph now all loss of life on our coast could possibly be avoided. An instance has been suggested to me only this evening by the chairman—the case of the Enterkin at the mouth of the Thames. I have inquired into the matter, and, as you know, a lighthouse was close to the spot where the wreck took place. I have ascertained beyond doubt that it would have been absolutely impossible, if there had been telegraphic communication between that lighthouse and the shore, for assistance to have reached the wreck from the shore in time to rescue the people who were drowning. The people were drowned within an hour of the time of the grounding of the ship, and no help could have reached them in less than three hours, But I do think, gentlemen, that something ought to be done in this matter. I do think that lives are lost now which might be saved if this communication existed in more places than it does. I do not think that you, as a Chamber of Shipping, although I do not agree with you in the desire to transfer the cost of maintaining the lighthouse service from the light dues to the general taxpayer, were justified in stating that this, at any rate, might be a national service and paid for by national funds; and I am convinced that this country will not grudge a very considerable expenditure in the effort to save life, especially in the effort to save life at sea, when a fair and reasonable inquiry has been made as to how that expenditure may be most profitably incurred. We shall propose to Parliament to make that inquiry, in order that something may be done, and in that I hope and believe we have the full sympathy of the Chamber of Shipping. All I would say further on this point is, that it is our duty as a Government, and as responsible to the taxpayers of this country, to take care that the question is justly and properly dealt with, and that, at the same time, it is dealt with in the way that becomes a rich country interested beyond any other country in its mercantile marine, and that does so much by voluntary exertions for the saving of life at sea."

BERLINER'S "ELECTRODES."

In the New York *Electrical Engineer* of January 20th, Mr. Barrett discusses the question of how far the Cuttriss helical carbon spring telephone transmitter (*The Electrician*, January 8th, p. 257) is new and outside the Berliner patent, recently issued by the United States Patent Office. It is first of all pointed out, as was done in our issue of January 15th by Mr. Campbell Swinton, that Edison devised a practically similar device in 1877, the material of the spiral not, however, being specifically mentioned. The question, "What are Electrodes in a Microphone Transmitter?" is next discussed. In the ordinary use of the word, "electrode" conveys decisively the idea of the separation, or at least the separability, of the two terminals of a metallic electrical circuit. Electrodes in constant contact with each other are technically an anomaly. But a special appropriation of the term has been made in Berliner's patent to a matter not within its strict technical acceptance, and a sufficiently intelligible definition for the purposes of the patent is given in the specifications of the patent itself, so that in all discussions of Berliner's patent and its relation to other patents, the term "electrodes" must be divested of its technical sense, and employed simply to designate those parts of the transmitter to which Berliner has applied it in his specifications. It is emphatically important not to allow the term in itself to convey any significance of the essential form, arrangement, or offices of those parts, but to be merely a symbol of reference to the drawings and specifications. Broadly speaking, the parts—those specially designated as electrodes—are certain metallic elements, between the several portions of which a constant contact is maintained. This contact is specifically stated to be constant; that is, continuous, and never to be interrrupted by the normal service of the transmitter, and means are provided for preserving this contact unbroken within the limits of such sonorous vibrations as the instrument is adapted to. Finally, Mr. Barrett comes to the conclusion that—"It may be held that Berliner's claims would surround any transmitter in which the continuity of the conductor is maintained, while the electrical resistance is increased through an elongation and constriction of the conducting path by the separation of short-circuiting areas of contact between mutually respective surfaces of portions of the resistance organism, and decreased by the reverse action. It is consequently not to be confidently asserted that the spiral-spring continuous-conductor short circuiting transmitter is a distinct type not infringing the Berliner claims."

LEGAL INTELLIGENCE.

In re The International Cable Company (Limited).

In the liquidation of this Company several questions arose as to the right of the Directors to remuneration in respect of their services, the most important point being whether they were entitled to claim remuneration during the period between the presentation of the winding-up petition and the making of the winding-up order at the same rate as if the Company were a going concern. The Company was incorporated in 1885 for the purpose of establishing, maintaining, and working certain lines of telegraphic communication. A material part of the Company's undertaking consisted of a concession from the Portuguese Government for landing and working submarine telegraph cables at the Azores from Great Britain, Ireland, and various other countries. Difficulties, however, arose in connection with this concession which resulted in its revocation by the Portuguese Government. A petition was accordingly presented on December 16, 1889, for the winding up of the Company, on the ground that the substratum of the Company was entirely gone. The Directors, however, entertained the hope that the concession might still be obtained, and accordingly they resisted the petition, and at the hearing his Lordship directed it to stand over until July. The hopes of the Directors, however, were not realised, and on the 26th of that month the usual winding-up order was made. The matter now came before the Court upon two summonses. The first was taken out by the liquidator, and by it he sought to make two of the Directors, Sir Alexander Armstrong and Mr. Mowatt, refund certain sums which they had paid to themselves in respect of their fees, on the ground that they had not acquired the necessary qualification shares entitling them to act as Directors. It appeared that the Articles of Association required each of the first Directors to hold 50 shares of £10 each or £500 stock, while all future Directors were to hold 100 shares of £10 each or £1,000 stock. It was admitted by the respondents, who were not first Directors, that they did not hold more than 50 shares each; but they relied upon certain resolutions which were passed by the shareholders on May 16, 1839, altering the Articles of Association in that respect, as a ratification by the Company of their appointment as Directors, notwithstanding they had not taken the necessary qualification shares. The second summons was by Sir A. Armstrong, and it raised the question as to his right to prove for fees in respect of the period between the presentation of the petition and the making of the winding-up order. Sir A. Armstrong claimed fees not only as a Director, but also as Chairman. The remuneration prescribed by the Articles was very large, the sum of £5,500 a year being divided among the Directors and Chairman and Vice-Chairman, and it was stated that similar claims by the other Directors were depending upon the decision in this case. As will be seen, his Lordship reserved his judgment upon the first summons, but disposed of such of the questions arising on the second as were not governed by the first.

Mr. Graham Hastings, Q.C., and Mr. Grosvenor Woods appeared for the liquidator; and Mr. Buckley, Q.C., and Mr. John Chester for the Directors.

At the conclusion of the arguments,

Mr. Justice STIRLING said that in this case there were two summonses. The first was by the liquidator, asking that the Directors might be ordered to refund certain sums which they had paid themselves. The other was by the Directors, seeking to prove in the winding-up for their remuneration subsequent to March 31, 1889, the date up to which they had so paid themselves. As to the first summons, his Lordship had made up his mind; but he did not propose to give judgment on the present occasion, because there was another case in which he intended to give judgment, and in which he would have to deal with the same authorities. As to the second summons he would also say nothing at present regarding that portion of it referring to the period prior to the date of the resolution reducing the qualification of Directors. But from May 16, 1889, when that resolution was passed, to December 16th, when the winding-up petition was presented, he was of opinion that proof ought to be admitted. As to the period from the presentation of the petition to July 26, 1890, when the winding-up order was made, he would order an inquiry in Chambers as to whether any and what remuneration should be paid to the Directors for the period between the presentation of the petition and the making of the order. Regarding Sir A. Armstrong's claim for the higher remuneration as Chairman of the Company, his Lordship held that Sir Alexander had never been formally elected Chairman of the Company within the meaning of the Articles of Association, and was, therefore, entitled to remuneration only as Director.

On the 10th inst., Mr. Justice STIRLING gave judgment on the remaining points. He pointed out that Sir A. Armstrong had told the Board that he

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would not accept office as Director unless the qualification was reduced to that of the earlier Directors. The Board seemed to have considered that a reasonable thing; but they could not decide the point. The Company only could do so by altering the Articles; and what the Board did was this: They said that at a particular time they would take the opinion of the shareholders; meantime they would not enforce against these gentlemen the obligations in the Articles of Association, as they were desirous that these gentlemen should give the Company the benefit of their services. His Lordship thought that all this was within the powers of the Directors, supposing them to have acted in good faith, and there was no suggestion that they had not so acted. In May, 1889, the Company did alter their Articles, and reduced the Directors' qualification to 50 shares. It had also been contended for the liquidator that Directors' remuneration must mean remuneration of "duly-qualified Directors." His Lordship could not adopt that contention; otherwise, a Director, who acted before attaining his qualification, under circumstances which might justify his so doing, would be deprived of remuneration for such services. That would not be reasonable; and instead of "duly qualified," the better words would be "duly acting as Director." In his opinion Sir A. Armstrong and Mr. Mowatt duly acted, and were entitled to remuneration accordingly. For these reasons the summons must be refused with costs.

National Telephone Company (Limited) v. John Milne and Son.

The action in the Dundee Sheriff Court at the instance of the National Telephone Company, against John Milne and Son, merchants, Dundee, for £8. 10s. of rent or subscription for telephone connection for the current year to November next (*The Electrician*, January 15, p. 282), came up again on Tuesday last. It was intimated that the case had now been settled, Messrs. Milne having paid the £8. 10s. sued for, and Small Debt Court expenses; the Telephone Company, on the other hand, agreeing to terminate their agreement with Messrs. Milne at November next if the latter desire.

Allison v. City and South London Railway (Limited).

In the Chancery Division of the High Court of Justice, London, on Tuesday, the case of Allison *v.* City and South London Railway Company again came before Mr. Justice Kekewich. In this case an injunction was asked for to restrain the defendants from so conducting their works at Stockwell as to be a nuisance to the occupants of the Stockwell Orphanage. At the trial last June, his Lordship adjourned the further hearing of the case in order that the Company might have an opportunity of abating the nuisance. Since then the Company have fixed a wooden roof under the iron roof over the vertical engines, bricked up the recesses in the engine-house wall, stopped the ventilators in the louvre of the roof facing the orphanage buildings, filled up the cavities in the foundations of the engines with solid material, and removed the Westinghouse air pumps from the engine-house walls adjoining the orphanage. The plaintiffs allege that the works executed have not abated the nuisance.

Mr. Renshaw, Q.C., and Mr. Ingle Joyce appeared for the plaintiffs; while Mr. Cozens Hardy, Q.C., and Mr. Graham represented the defendant Company.

After some discussion, and at the suggestion of his Lordship, it was agreed that Mr. Harris, partner in the firm of Sir F. Bramwell and Co., should visit the spot and see what had been done and inform the Court whether the works caused any annoyance by noise or vibration; and if so, whether it could be removed by any alterations or modification in the buildings.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.

The tenth annual edition of the above well-known annual is now ready, price 7s. 6d.; post free, in the United Kingdom, 8s. 3d.; abroad (with the exception of a few countries), post free, 8s. 10d.

The edition consists of between 900 and 1,000 pages, and special care has been taken to make the Directorial division of the book, which has been considerably extended, thoroughly accurate and reliable.

To the Handbook division has been added several features which will be found of service to the Electrical and Allied Trades. The Digest of the Law of Electric Lighting has been thoroughly revised and brought up to date, and the most recent Board of Trade Regulations are also included. The various tables and tabulated statements relating to Central Stations, Electric Railways and Tramways, &c., have been made complete; the tables giving useful data relating to dynamos, alternators, motors, transformers, batteries, &c., have been remodelled and amplified, with the object of giving fuller particulars than hitherto relating to the principal makes of dynamos and other electrical machinery and plant. A new feature is the tabulation of valuable information respecting Electrical Limited Liability Concerns; no labour or expense has been spared to make this information complete, and we believe that this new feature will be found of great service to electrical firms having business dealings with the companies referred to. The information given respecting the Local Authorities of Great Britain has been perfected, and is thoroughly reliable.

An important feature is the space devoted to the officials of Foreign and Colonial Governments who have the superintendence of contracts and the giving of orders for electrical plant and apparatus; and as this has been kindly supplied by the various Government departments, it can be relied upon, as can also the particulars given respecting the Home Government departments.

As our readers are aware, the DIRECTORY is due at the end of January, and, as a matter of fact, is kept posted up to within two or three days of the date of publication, as is evidenced by the inclusion of several new firms and changes of address which have only taken place at the extreme end of January, 1892.

The profession will find "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK a trustworthy work of reference, and purchasers of plant and apparatus may confidently turn to its pages for the names of all the principal firms supplying their requirements. Nearly every firm of any standing in the Electrical and Allied Trades is represented in its advertisement pages.

A digest of the contents of the book will be sent on application.

TENDERS INVITED.—Applications are invited by the Llanelly Local Board for taking over the powers vested in the Board by a Provisional Order obtained last Session for the supply of electricity within the District of the Borough of Llanelly. Applications are to be addressed to the Clerk of the Board, Mr. J. Jennings, before March 5th.

——— The Town Council of Bideford also invite tenders for lighting the town and suburbs. Particulars of Mr. C. W. Hole, town clerk.

TENDERS ACCEPTED.—The Aston Local Board has accepted the tender of Messrs. Fowler, Lancaster and Co. (Limited) to substitute the electric light for gas at the public baths, for the sum of £1,594.

MESSRS. ERNEST SCOTT & MOUNTAIN (LIMITED) ask us to state that they are not affected by the strike on the Tyne.

MESSRS. DOLLOND & CO.—This firm have opened a department for the sale of electrical apparatus, which is under the management of Mr. F. Berrett.

THE FRANKFORT EXHIBITION.—The Committee's Official Report on the Exhibition and the Official Report of the Jurors will be published shortly. Each Report will contain about 400 pages, 4to, and will cost about £1 (postage additional). The Official Report of the International Electrical Congress will not be ready until later, and will cost about 15s., including postage. Subscription orders for these Reports (which will be in German) can be sent to the Publisher of *The Electrician*.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

FEBRUARY 1, 1891.

1,876. R. KENNEDY. Glasgow. Improvements in alternating-current electromotors.

1,878. F. DAVIS and R. E. B. CROMPTON. London. Improvements in means or apparatus for protecting underground electrical conductors.

1,880. A. B. WOAKES. London. Improvements in electrical sound-producing apparatus.

1,883. W. LUCAS and T. A. GARRETT. London. Improvements in electrical telephone transmitters.

1,906. J. G. BYWORTH. London. Improvements in shades for electric lamps.

1,908. T. B. GRANT. London. An improved form of automatic accumulator, charging switch, and safety cutout.

1,924. G. S. GRIMSTON. London. An electric switch.

1,927. W. J. S. BARBER-STARKEY. London. An improvement in secondary voltaic batteries.

February 2, 1892.

2,008. E. RATHBONE. Liverpool. Improvements in electric light decorations.

2,012. G. W. HART. London. Improvements in synchronous electrical signalling apparatus.

2,016. J. PRICE, junior. London. An improved block for use in forming conduits for electrical or other cables or wires, and for analogous purposes.

2,017. G. TURNER. London. A new or improved method of and means for making zinc rods for electric bells and batteries.

2,020. C. W. CATT. London. Improvements relating to electrical signalling on railways.

2,026. H. H. LAKE. London. Improvements in electric telephones. (E. A. Grissenger and T. Grissenger, United States.)

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2,055 W. L. WISE. London. Improvements in or relating to apparatus for closing electric circuits, for use in connection with position finders or the like. (G. Bertolini, Italy.)

February 3, 1892.

2,064. W. D. PARR. Sheffield. Improvements in the construction of electro-pneumatic presselles for electric bells and signals.

2,106. H. HOWARD. London. Improvements in heating and welding by electricity.

2,109. F. T. HOLLINS. Leytonstone. Improvements in arrangements and apparatus for telegraph message signalling and other purposes.

February 4, 1892.

2,162. R. E. B. CROMPTON and E. A. N. POCHIN. London. Improvements in automatic arc lamps used in projectors or search lights.

2,163. R. E. B. CROMPTON. London. Improvements in electric measuring apparatus.

2,198. F. THORNTON and LATIMER CLARK, MUIRHEAD AND CO. (Limited). London. Improvements in culverts for electric mains.

February 5, 1892.

2,225. G. NAHNSEN. Berlin. Improvements in the method of purifying electrolytes containing zinc, relating to or connected with the electro-metallurgic production of zinc.

2,254. W. P. THOMPSON. Liverpool. Improvements in or connected with the holders of incandescent lamps. (M. Fuss, Germany).

2,260. H. H. LAKE. London. Improvements relating to the heating of metals by electricity and to machines therefor. (G. D. Burton, A. H. Eddy, and G. S. Briggs, United States).

2,278. T. C. MOORE. London. Improvements in and relating to electroliers or pendants and standards for electric lamps.

2,283. B. J. B. MILLS. London. Improvements in systems of electrical distribution. (H. W. Leonard, United States).

2,290. E. E. RIES. Baltimore, United States. Method or process of electric riveting.

February 6, 1892.

2,293. D. TURNER. Edinburgh. Improvements in the method of connecting together the cells in medical and surgical batteries.

2,312. B. M. DRAKE, J. M. GORHAM, and J. SAWORD. Westminster. Improvements in shade carriers for electric lamps.

2,329. O. IMRAY. London. Improvements in process and apparatus for bleaching by electrolysis. (T. J. Montgomery, United States.)

2,330. E. A. GIMINGHAM. London. Improvements in electric switches.

2,336. H. DOYER. London. Improvements in dynamo electric machines.

SPECIFICATIONS PUBLISHED.

1891.

1,804. REDFERN. (W. Lahmeyer and Co.) Electric motors. (Price 8d.)

2,732. WHITE. Electric lamps. (Price 6d,)

3,467. MUNNS. (Smith.) Galvanic battery. (Price 8d.)

4,235. FLETCHER. Electric telegraph transmitters. (Price 8d.)

4,292. ENTWISLE. Electrical bell, &c. (Price 8d.)

4,471. WHITE. Electrical switchboards, &c. (Price 6d.)

4,482. PRICKETT. Telephonic switchboards. (Price 8d.)

4,678. PITKIN. Electrical terminals. (Price 4d.)

4,757. WILLSON. Electric reduction of aluminium, etc. (Price 8d.)

4,781. ENGLEDUE. Galvanic batteries. (Price 4d.)

4,877. LAKE. (Street and another.) Electric batteries. (Price 6d.)

10,307. COERPER. Dynamo-electric machines. (Price 8d.)

19,233. MUNSIE. Electric railways. (Price 11d.)

20,936. DEWEY. Electric heating. (Price 8d.)

21,245. CLERC AND OTHERS. Electric alarm, etc., clocks. (Price 6d.)

21,870. LAKE. (Clark.) Voltaic cells. (Price 6d.)

21,961. LAKE. (Cuttriss.) Relays, telephones, etc. (Price 8d.)

COMPANIES' MEETINGS.

Cuba Submarine Telegraph Company (Limited).

The forty-first ordinary general meeting of this Company was held on Wednesday last at the Company's offices, 58, Old Broad-street, under the presidency of Mr. Thomas Greenwood.

The SECRETARY (Mr. James Scott) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, the accounts which the Board has the honour to submit for your approval to-day resemble very much those that were presented twelve months ago, the difference on either side being very small. Our income has been £350 more than in the corresponding period of last year, while we have saved about £50 in our working expenses. This gives us £370 to the good, comparing one half-year with another. We have taken from the balance £170 more, which enables us to put to the reserve fund £5,000 for the half-year, as against £4,450 in the corresponding period of the previous year. We have been enabled to do this because we have been very fortunate this half-year in having had no interruption to our cables. No amount whatever has been expended in repairs. Of course that £5,000 goes to the reserve fund against repairs, the average of which will be about £3,000 each half-year. The report is remarkably short, and contains all that is to be said; and unless some shareholders may have some inquiries to make, I do not know at this moment what further information I can give you; therefore, I shall move:

"That the report and accounts for the half-year ended 31st December last, now submitted, be received and adopted."

Mr. ALEXANDER F. LOW: I beg to second the resolution.

The Rev. J. W. BROWN: Before putting the report to the meeting, I should like to ask two questions. The first is with regard to the reserve fund. What is the maximum amount to which it is proposed to be raised? The next is with respect to deposits with banks and other investments. I wish to ask whether in your opinion, and in the opinion of your brother Directors, the sum of £8,000 said to be deposited in the English Bank of the River Plate may be taken at that figure?

Mr. COCHRAN: Will you kindly give us some explanation as to the law expenses, and whether they have occurred in connection with the case at Madrid?

Mr. W. GRIFFITH: The reserve fund at the present time is an important consideration. You tell us that the average cost of the repairs of the cable each half-year would be about £3,000. The interest of the reserve amounts to that sum, and to me it certainly seems time that the shareholders should enjoy the benefit of all the profits made upon their capital. I am certainly in favour of insuring our property against any risks; but if the average expenses for repairs do not amount to more than £3,000, and the income from the reserve fund already exceeds that amount, I think you have reached a point when the reserve is as large as it ought to be. There is also another argument in favour of this. We have been fortunate in having our cables constructed by a company that leases to us, so that we can have a cable on lease. That is another reason why we should not have so large a reserve as other companies less favourably situated. How long have we to pay rent for the cable of 1881, which will ultimately become our property? A previous speaker has alluded to the law expenses. Will you kindly give us some information as to the action referred to, and the likelihood of our success? The shares of the Company are at a low price in the market compared with what they were last year. I should be obliged to you if you would tell us the reason why they are lower now than then.

The CHAIRMAN: I shall be very pleased indeed to answer fully all the questions and observations made; and I shall be able, I hope, to do so not only fully but satisfactorily. I shall answer the smaller questions first. The law charges were the whole of the expenses that have occurred in connection with the case at Madrid. With respect to the 1881 cable, it was taken on lease from February 17, 1881, for 12 years, and the payment of £1,875 for the half-year will expire on February 17, 1893—a little more than twelve months from now. As regards the maximum to which it is intended to bring up the reserve fund, the matter has been mooted on several occasions, and I think the late Chairman gave an intimation that it was desirable that it should be added to until we had received the sum of, at least, £100,000. I think it will be then wise for the shareholders, with the Board, to take into consideration—if they are in a position to have £5,000 available—what is to be done with the money. But I strongly recommend that we should continue the course we have adopted until we have raised the reserve to £100,000. As regards the deposits with the Bank referred to, I was elected by the creditors on the committee of inspection of that Bank, and the High Court of Judicature approved of what the creditors had done. In fact, I am the chairman of that committee. I have taken a prominent position, therefore, and an active part in the preparation of a scheme for the resuscitation of the Bank. It is now under the consideration of solicitors, and is practically, though not absolutely, agreed to by all the members of the committee. It involves the payment to every creditor of twenty shillings in the pound by instalments, and interest on the unpaid instalments until the whole amount is paid. If the scheme is carried out, we shall recover the whole of our money and interest on it. Regarding the possibility of getting new cables laid for us upon the same terms as those of the 1881 cable, I can hold out no hope whatever. We tried it when we laid our last new cable, but we were not able to make terms with the contractors similar to those we made in 1881, because at that time the contractors had a cable prepared which they were unable to dispose of, and they were only too glad to get rid of it. That is not the case now, and probably never will be again. As to the necessity of holding a reserve fund, you are aware that for some years past we have been threatened with opposition. That opposition has gone so far as to obtain from the Spanish Government a concession for the making of a line on the other side of the island of Cuba, which would be in direct opposition to us. We are now receiving from the French Company a large traffic, and we reduced our rates 25 per cent. some little time ago to try to secure it, and prevent the French Company from taking steps to extend their lines, because we hoped to satisfy them that it was impossible to lay a cable and carry messages at less cost than we were doing. I am afraid that we have not succeeded in that. The Board, however, are prepared to make a further reduction if, by so doing, they can secure the traffic. We hold that it is much better to make a reduction and keep the whole of the traffic than not to make a reduction, and be driven to make it afterwards by competition, after part of the traffic would be taken from us. The French Company, by getting that line, would do us a very serious injury, but we have very great hopes that our concession will not be interfered with. I think that can be the only explanation I can give of the reason why the shares in the market have been reduced to the price at which they now stand. But while we pay 8 per cent. on our capital and put by a reserve of £10,000 a year it is nonsense to quote our shares at their present prices unless there was an idea that something was going to happen to the Company. There is a possibility, but I don't think a probability, of a combination being brought against us.

The resolution was then carried *nem. con.*

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The CHAIRMAN next proposed :—

"That the following dividends for the half-year be now declared upon the shares of the Company, viz., at the rate of 10 per cent. per annum, subject to income-tax, on the Preference Shares, and 8 per cent. per annum, free of income-tax, on the Ordinary Shares, payable on and after to-morrow."

Mr. C. W. PARISH : I beg to second that.

The resolution was carried unanimously.

Mr. GRIFFITH : I beg to propose a vote of thanks to the Chairman and Directors.

Mr. CURRY : I beg to second that.

The CHAIRMAN : I thank you on behalf of my colleagues and myself. We are pleased to find that what we have done meets with your approval, and you may rely upon it that everything that can be done in future to promote your interests will be done.

The proceedings then terminated.

Giant's Causeway, Portrush and Bush Valley Railway and Tramway Company (Limited).

The sixteenth annual meeting of this Company was held last week at the offices, Portrush, Dr. A. Traill in the chair, when the Directors' Report was adopted and the retiring Directors, Mr. C. M'D. Stuart and Mr. W. A. Traill, C.E., were re-elected.

The following is from the Directors' Report :—

"Your Directors beg to submit, for the approval of the shareholders, their annual report to December 31st, 1891, which completes the ninth year since the line was opened for traffic. Your Directors are glad to be able to report another large increase in the passenger traffic in the year, the first-class passengers having increased to 9,292 from 8,943 last year, and 7,845 in 1889; and the third-class passengers having increased to 82,406 from 73,859 last year, and 56,822 in 1889—the total for the year being 91,698, with corresponding receipts, amounting to £2,830. 4s. 2d., as against a total of 82,802, with receipts £2,579. 19s. 5d. in 1890, and a total of 64,669, with receipts £2,338. 11s. 7d. in 1889. The goods and mineral traffic amounted to 181 tons, compared with 316 tons in 1890, and the receipts have been respectively £29. 1s. 5d. and £41. 8s. 11d. The receipts for parcels and miscellaneous traffic have diminished during the year from £77. 7s. to £19. 19s., so that the total receipts from the revenue account have been £2,895. 14s. 7d., as against a total of £2,698 15s. 4d. in 1890. There has, however, been considerable increase on the expenditure side of the account, which shows a total of £1,945. 6s. 6d., as against £1,687. 12s. in 1890, and £1,732. 10s. 9d. in 1889. There is consequently a credit balance on the result of the year's working of £950. 8s. 1d., as against £1,011. 3s. 4d. in 1890, and £381. 18s. 7d. in 1889. This result has again fulfilled the anticipations of the Directors, and is traceable not only to the increase in the passenger traffic, but to the alteration made three years ago in the arrangements with regard to the goods traffic, which had previously been a constant source of loss to the revenue. It will be seen, on an examination of the above figures, that the ratio of expenses to receipts, which was 82 per cent. in 1889, and 62 per cent. in 1890, has been 67 per cent. in the past year. The value of electricity as a locomotive power, when generated by water power, as compared with steam, continues to be shown remarkably. The expenses of the electrical working amounted to £314 for 19,863 miles run, or less than 4d. per mile, while steam power cost £635 for 12,280 miles run, or 1s. 0½d. per mile. Your Directors regret the considerable increase in expenditure during the year, but they have found it necessary to re-fence the line for almost its entire length, to prevent accidents to cattle. They have also paid for the conversion of three waggons into cars out of revenue, and have spent a considerable sum in the renewal of the electrical apparatus; and, as the permanent way and steam engines have been kept in complete order, everything will be found in proper condition for the ensuing season. Your Directors regret that they are not yet in a position to offer a dividend to the shareholders, nor can they do so until the net revenue account is brought into a more favourable position; but they think it is evident from the great improvement which has taken place in the finances of the Company during the last two years, that the time is approaching when they will be able to do so."

Liverpool Overhead Railway Company (Limited).

The half-yearly meeting of the shareholders of this Company was held on Wednesday, at Liverpool; Sir W. B. Forwood presiding.

The CHAIRMAN, in moving the adoption of the Directors' report, which will be found below, said that up to date there had been a total expenditure on the construction of the railway of £257,261. Some delay had been caused in consequence of a strike at the works, where some of the girders were being made; but they were now making rapid progress, and they hoped to have the railway complete and open for traffic some time during the autumn. The Directors had lately visited the Electric Construction Corporation Works at Wolverhampton, where the electric plant was being made. They found that the electric plant was well advanced, and that the Corporation were taking very great trouble and care in testing every piece of the machinery, so that when it was delivered they hoped there would be no breakdowns. The generating station would be in the dock line of railway at the Bramley Moore Dock. They had leased a piece of land from the Dock Board and it was in an exceedingly convenient place. They had no necessity to erect any buildings. Their generating machinery, boilers, steam-engines, and dynamos were directly under the coal railway above. They would obtain the coal at a very low cost, because it dropped down from the railway above directly into the boiler pits, and they would also be able to draw water for condensing and other purposes directly from the dock alongside. It was impos-ible to conceive that electricity could be generated at any lower cost than by the method they were adopting. Tenders for the stations had been received, and would be at once considered by the Directors.

The motion having been unanimously adopted, and the retiring Directors and auditor having been re-elected, the meeting was then resolved into a special meeting, when it was resolved to raise the sum of £75,000 by the issue of a Four per Cent. Debenture Stock.

A third meeting of the shareholders was afterwards constituted, at which a resolution was passed approving of a Bill being introduced into Parliament for extension of time in constructing the railway and to make certain extensions.

The following is the Directors' report adopted by the ordinary general meeting :—

"The Directors have pleasure in being able to report that the main structure of the overhead railway had been advanced to St. Nicholas'-place, where the bow-string spans, intended to carry the line across this space, are in the course of erection. The foundations for the southern section are nearly completed, and many of the columns and cross-girders are in place, and as soon as St. Nicholas'-place is crossed, rapid progress will be made with this portion of the work. Arrangements have been made with the Dock Board to lease a site for the electric generating station at the Wellington Dock; the position immediately under the coal railway and adjoining the dock affords very exceptional facilities for the economical production of electrical power. The electrical equipment and rolling stock are well advanced towards completion.

"The balance brought forward from last half-year to the credit of revenue account was £1,447. 7s. 10d., to which must be added interest allowed by the Company's bankers, &c., £126. 17s. 1d., making a total of £1,574. 4s. 11d.; after deducting £198. 4s. 7d. for interest on amount paid in advance of calls, and cost of administration £462. 12s. 5d., there remains a credit balance of £913. 7s. 11d.

"The Directors retiring by rotation at this meeting are Mr. James Barrow, Mr. Edward Lawrence, and Mr. G. H. Robertson, and, being eligible, offer themselves for re-election. The auditor retiring by rotation is Mr. George Nicholson, who is also eligible for re-election."

NEW COMPANIES, STATUTORY RETURNS, &c.

CANNINGTON, SHAW, AND CO. (LIMITED).—Registered with a nominal capital of £250,000, divided into 2,500 shares of £100 each. Object : To acquire (as from January 1, 1892) as a going concern the business of glass manufacturers, now carried on under the style of Cannington, Shaw, and Co., at the Sherdley Glass Works and the Peasley Glass Works, both situate at Sutton, near St. Helen's, Lancashire.

ROTARY ENGINE SYNDICATE (LIMITED).—This Company was registered on February 8, 1892, as a Company limited by guarantee. For the purposes of registration the number of members is declared to be 100, and should the Company be wound up each member is liable for £20. The objects are to apply for, purchase, or otherwise acquire, any patents, licenses, concessions, &c., and in particular to acquire the inventions for (*a* "an improved rotary expansive steam engine or pump," and (*b*) "improvements in rotary fluid-pressure engines, applicable also as pumps," and to carry on the business of general, mechanical, manufacturing, civil, marine, and electrical engineers, metal founders, machinists, metallurgists, &c. Registered office : Castle Chambers, Apie-street, Norwich.

SHARON CHEMICAL COMPANY (LIMITED).—This Company was registered on February 3, 1892, with a capital of £7,800, divided into 750 ordinary and 30 founders' shares of £10 each, by Waterlow and Sons (Limited), 83, London-wall, London, E.C. The objects are to purchase and take over, as a going concern, the business of chemical manufacturers, carried on at Little Chester, Derby, under the style of "The Sharon Chemical Company," and to carry on the business of analytical and manufacturing chemists in all its branches; to generate for the purposes thereof electricity, gas, or other power, and to use the same. The number of Directors is not to be less than two nor more than five. Qualification, £750. Remuneration of above Directors, £250 each per annum.

TAVERNIER'S FRENCH PATENTS (LIMITED).—This Company was registered on February 3, 1892, with a capital of £1,200 in £1 shares, by Williams and Neville, 23, Austinfriars, London, E.C. The objects are to acquire from [Alphonse][Edouard] Tavernier an invention described as an electrical apparatus for the automatic indication of fire, and of the rise of temperature in the bearings of machinery, and for simultaneously supplying oil where required; to acquire any other invention, addition, or improvement, and to utilise and turn to advantage the said inventions, brevets d'invention, rights and privileges by manufacture and sale, grants of licenses to manufacture and sell, by further development, &c. The Regulations of Table A. mainly apply.

TROTT PATENT VALVE AND ENGINEERING COMPANY (LIMITED).—This Company was registered on February 3, 1892, with a capital of £50,000, divided into 49,500 ordinary and 500 founders' shares of £1 each, by Lickorish and Bellord, 11, Queen Victoria-street, London, E.C. The objects are to enter into an agreement with Herbert Trott, for the purchase of certain letters patent, trade marks, rights and premises, to carry on the

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business of manufacturers and vendors of Trott's patent valves and apparatus, and generally to carry on the business of iron, brass, and metal founders, fitters, mechanical engineers, manufacturers of agricultural machinery and implements, tool makers, metal workers, boiler makers, iron and steel converters, electrical, hydraulic, sanitary, marine, gas, and water supply engineers and suppliers of electricity for all purposes.

MISCELLANEOUS.—Amongst the new Companies recently registered which propose dealing in some way or other with electricity, are—

Kennedy Dry Press Brick Machine Syndicate (Limited); capital, £15,000.
Pontnewynydd Freehold Land Building and Cottage Company (Limited); capital, £25,000.
W. Summerscales and Sons (Limited); capital, £50,000.

AUTOMATIC ELECTRICAL CORPORATION (LIMITED).—The annual return of the above-named Company, made up to January 14, 1392, was filed on the same day. The Company was registered on June 7, 1888, with a capital of £75,070 in £20 shares, to act as undertakers for the supply of electricity for lighting and other purposes within the United Kingdom and elsewhere, and to erect and manufacture apparatus for the generation and supply of electricity. At the time of making-up all the shares had been taken up, and upon 7 of these the full amount had been called and paid. The remaining 3,743 shares have been issued and considered as fully-paid. Registered office: Winchester House, Old Broad-street, London, E.C.

BARNET AND DISTRICT ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 12, 1892, was filed on the same day. The Company was registered on August 25, 1888, with a capital of £5.0 0, divided into 490 ordinary shares of £10 each, and 100 founders' shares of £1 each, to acquire all the rights, benefits, and advantages of H. F. Joel, under a contract with the Barnet Local Board, for the lighting of the district of the Board by electricity, and the supply of electricity to shops, private houses, and other buildings, and to carry on the business of an electric light, heat and power supply Company in all or any of its branches. At the time of making up 80 ordinary and 100 founders' shares had been taken up, the founders' shares having been issued as fully paid. Upon 60 ordinary shares the full amount has been called, and upon the remaining 20 £5 per share has been called, and all calls have been paid. Registered office: 31, Wilson-street, Finsbury, London, E.C.

BRITISH ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 13, 1892, was filed on January 21st following. The Company was registered on October 4, 1878, with a nominal capital of £100,000, in £10 shares, for the "bringing into public notice the advantages of electric force and power as an agent in producing light for general illuminating purposes, and extending its adoption and use for such purposes, and the acquisition of gain and profit by employing, using, and utilising electric force and power as an agent in producing light, and the utilising of light so produced for general lighting and illuminating purposes." The Company filed returns regularly until January 19, 1886; and on Saturday, February 13, 1886, in the High Court of Justice, Chancery Division, upon the petition of S. S. Stott and Co., engineers, of Laneside Foundry, Haslingden, Lancashire, Mr. Justice Pearson ordered that the Company be wound up under the provisions of the Companies' Acts, 1862 and 1867. On Wednesday, Sept. 26, 1888, however, in the High Court of Justice, Chancery Division, upon the petition of H. T. Edwards, the official liquidator of the Company, Sir James Hannen (for Mr. Justice North) ordered that all further proceedings in the winding-up of the Company should be stayed, and the Court sanctioned a scheme of arrangement with the debenture holders, unsecured creditors, and shareholders, by which "the unsecured creditors should respectively accept fully paid-up preference shares, carrying interest at 10 per cent. per annum, for amounts equal to 50 per cent., or one-half of their respective debts or claims against the Company, in full satisfaction and discharge of such debts and claims respectively." At the time of making up (January 13, 1892), 8,640 shares had been taken up, of which 1,144 had been issued as fully-paid; upon the remaining 7,496 the full amount has been called and paid. Registered office: 11, Delahay-street, Westminster, London, S.W.

CLEGG'S METAL INCANDESCENT LAMP COMPANY OF FRANCE (LTD.).—The registered offices of the above-named Company, which was registered on May 20, 1891, with a capital of £10,000 in £10-shares, have been removed from Wharf-road, City-road, London, and are now situate at Connaught-mansions, Victoria-street, Westminster, London, S.W.

COLUMN PRINTING TELEGRAPH COMPANY (LIMITED).—Although this Company was registered on June 5, 1890, no information respecting its shareholders has been filed. The capital of the Company is £100,000, in £1 shares, and the Directors were the Right Hon. the Earl of Wharncliffe, Viscount Lymington, Hon. Arthur Brand, W. H. Hurlburt, and R. Pryor. Registered office: 5, New Bridge-street, London, E.C.

ELECTRIC METER COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 13, 1892, was filed on January 21st following. The Company was registered on March 22, 1890, with a nominal capital of £50,000, in £10 shares, to enter into an agreement with the Corporate Trust (Limited) for the sale to the Company of certain letters patent relating to electric meters and other rights, and to carry on the business of electricians, mechanical engineers, manufacturers of any kinds of electrical apparatus and appliances, workers and dealers in electricity, motive power, and light, telegraph, cable, and telephone manufacturers, &c. At the time of making up, 2,007 shares had been taken up, of which 2,000 were issued as fully paid. Upon the remainder the full amount has been called, resulting in the payment of £30, and leaving £40 in arrears. Registered office: 25, College-hill, Cannon-street, London, E.C.

LAW'S ELECTRICAL APPLIANCES COMPANY (LIMITED).—The statutory return of the above-named Company, made up to February 3rd, 1892, was filed on February 5th following. The Company was registered on September 23rd last, with a capital of £4,000 in £5 shares, to acquire and work certain patents for "Improved methods for facilitating the publication of news," "Improvements in apparatus for operating or controlling type-writers, type-setting machines, and the like by the aid of electricity," "Improvements in and relating to electrical switches, chiefly designed for use in connection with apparatus for obtaining synchronous movements," belonging wholly or in part to Edward Fitzgerald Law. At the time of making up, 793 out of the 800 shares had been taken up, of which 786 had been issued as fully paid. Upon the remaining 7 no calls have been made. Registered office: 2, Jackson-road, Holloway, London, N.

RICHARD HORNSBY & SONS (LIMITED).—The annual return of the above-named Company, made up to December 23, 1891, was filed on December 30, 1891. The nominal capital is £400,000, divided into 30,000 ordinary shares of £10 each and £100,000 worth of Preference stock. The 30,000 ordinary shares and all the Preference stock has been taken up, and upon the ordinary shares £8 per share has been called and paid, while the whole of the Preference stock has had the full amount called and all calls paid, the amount paid being £340,000.

CITY NOTES, &c.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to allow this Company's 5,004 additional preference shares, Nos. 69,997 to 75,000, to be quoted in the Official List.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—Mr. James Staats Forbes, the Chairman of the London, Chatham and Dover Railway Company, in addressing the shareholders at the ordinary meeting at the Cannon-street Hotel on Friday, said that the Company had to contend with most serious competition of omnibuses, tramways, and electric railways. The latter were no doubt matters of great public convenience. The only one which was now working in London was, he believed, the City and South London Railway, which ran for some distance parallel to the line of their railway. That Company had just published their report, and he hoped that the people who had put money into that enterprise would find comfort in the report that had been issued. They had carried a very great many passengers who would no doubt, had that railway not existed, have gone over their Company's system; but he did not think that they had done very much good for themselves: but still, it was a great convenience to the public. The Chatham line must to some extent have suffered in consequence, and they were not the only sufferers because it had also affected the tramway companies on the other side of the water, who had had to reduce their fares, and who, he believed, for some considerable distance south of the river were now carrying their passengers for ½d., in consequence of the competition of the electric line. The London, Chatham and Dover Company could not afford to carry people on their railway for ½d., neither could they afford to carry them for 1d., because the people who wanted to travel in large numbers at ½d. and 1d. required to travel at the very hours of the day, coming into London and going out of London, that the high-class people—the long-distance traffic people—required to get in and out; and therefore it was a question of selection, and they could not sacrifice the long-distance and paying traffic for the advantage of the masses. He had no hesitation in stating as a proposition that no company could make a railway, whether it was under ground or whether it was over ground, in London for local accommodation at these low fares that could possibly pay.

The declaration of the result of the poll demanded at the shareholders' meeting held last week (see *The Electrician*, Feb. 6, p. 368) took place on Tuesday last, at the office of the Company, 46, King William-street, E.C., when the Chairman (Mr. Chas. Grey Mott) announced that the resolution had been carried by a large majority.

The traffic receipts for the week ended February 7th amounted to £824, as against £702 for the corresponding period of 1891, an increase of £122. The total receipts to date, from January 1, 1892, are £4,475, against £4,033 in the corresponding period of 1891, an increase of £442.

CITY AND WATERLOO RAILWAY COMPANY (LIMITED).—Mr. W. S. Portal, the Deputy-Chairman of the London and South-Western Railway Company, in the course of his speech at the annual meeting held on Thursday last, referred to the Waterloo and City Railway Bill, and said that the most important of the Bills the progress of which they were watching through Parliament was the Waterloo and City Railway Bill, which it was manifestly in the interest of their Company to support. This Bill was promoted in the present Session of Parliament for powers to make an underground railway from Waterloo Station to the City, the terminus of the same to be very close to the Mansion House. The promoters of that Bill took powers under the Bill to enable them to enter into arrangements with the London and South-Western Railway Company. They had no doubt whatever that if such a Bill were approved and the railway made, it would be of immense advantage for the improvement of the residential traffic of the London and South-Western Railway, and altogether they considered that it would be of great benefit to that Company. For many years past they had been twitted with the fact that they landed their City passengers at Waterloo Station, and did not carry them on to the City. They had had many schemes submitted to them for carrying out this purpose, and they had always brought to bear a large amount of attention upon this important subject; but they had arrived at the conclusion that it would not be wise

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to incur an expenditure of some £3,000,000 or £4,000,000 of money which they would have to do in order to make this line. But *tempora mutantur!* Science was not stationary, and with the progress of electrical science had come the possibility of constructing this line for something like only half a million of money. At the special meeting which followed the general meeting it was unanimously resolved to support the Bill.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—The Stock Exchange Committee have ordered the vendors' shares, Nos. 45,101 to 50,000, to be quoted in the Official List.

GREAT NORTHERN TELEGRAPH COMPANY (LIMITED).—The traffic returns of this Company in January, 1892, were £20,000; corresponding month, 1891, £20,800; 1890, £19,600.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to allow this Company's 10,000 additional Seven per Cent. Preference shares, Nos. 30,081 to 40,080, to be quoted in the Official List.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—Subject to the audit of the accounts, the Directors propose paying a dividend of 15 per cent. (£1. 16s. per share), in addition to the 5 per cent. already paid, making 20 per cent. for the year 1891.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to, this Company's £80,000 Five per Cent. First Mortgage Debentures (1917).

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Divi-dend.	Name.	Previous Week's Price, Feb. 3.	Price Wednesday, Feb. 10.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Feb. 10. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/6	Anglo-American	50 51	50 51	5 2 8	Jan., Apr., July, Oct.	50½	49½
£2,849,510	Stock	25/0	Do. Preferred	89 90	89 90	5 16 4	" "	90	89
£2,849,510	Stock	5/0	Do. Deferred	12½ 13	12 12½	..	" "	12⅝	12
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10½ 11	10¾ 11½	7 2 3	Mar., June, Oct., Dec.	11 1/16	10⅝
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 5	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	153 157	153 157	4 9 2	Jan., Apr., July, Oct.	154	153½
16,000	10	8/0	Cuba Submarine	10 11	10½ 11½	6 19 2	February and August	10¾	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3¼ 3¾	3¼ 3¾	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	8½ 9½	8½ 9½	5 5 3	" "	9¼	9
60,710	20	3/6	Direct United States	11 11¼	11 11¼	6 5 0	Jan., Apr., July, Oct.	11¼	11
400,000	10	2/6	Eastern	14⅜ 14⅝	14⅜ 14⅝	3 16 0	" "	14⅝	14½
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15 7/16	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107 110	107 110	3 12 9	May and November	109¼	107½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	105 108	105 108	4 12 7	February & August	..	..
250,000	10	2/6	Eastern Extension	15 15¼	15 15½	4 11 10	Jan., Apr., July, Oct.	15 7/16	14⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	February & August	106¼	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101 104	101 104	4 16 2	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	98 101	98 101	3 19 3	Febuary and August	..	..
180,227	10	1/6	Globe Telegraph and Trust	9⅞ 10½	9⅞ 10½	5 6 2	Jan., Apr., July, Oct.	10½	9 13/16
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15	14⅞ 15	4 0 0	" "	15	14⅞
150,000	10	5/0	Great Northern	19 19½	19 19½	4 7 2	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106 109	106 109	4 11 9	March & September	108	107½
17,000	25	12/6	Indo-European	41 43	41 43	5 16 3	May and November	41⅞	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	7½ 8	7½ 8	5 3 2	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	116 121	115 120	5 0 0	" "	116½	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	101 104	101 104	4 6 7	March & September	104	102
30,000	10	2/0	West Coast of America	4 5	4 5	..	January and July ..	4⅝	..
£150,000	100	8%	Do. Debentures 8% 1902	101 105	101 105	7 12 5	June and December	104	..
88,321	10	1/0	West India and Panama	1⅝ 1⅞	1⅝ 1⅞	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 10	9½ 10	6 0 0	May and November	9 15/16	9 13/16
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8½ 9½	8½ 9½	6 6 4	" "	8 11/16	..
67,007	15	6/0	Western and Brazilian	10 10½	10½ 10⅝	7 2 10	" "	10⅝	10 7/16
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6½ 6⅞	6½ 6⅞	5 7 3	" "	6⅞	6 5/16
30,364	7½	7/6	Do. 5 per Cent. Deferred	4 4½	4 4½	..	" "	4¼	4
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	101 104	101 104	5 15 5	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	101 104	101 104	5 15 5	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜ ½	⅜ ½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16 1/16	1/16 1/16	6 3 11	Yearly	..	..
438,984	5	2/6	National	4½ 4⅝	4½ 4⅝	6 17 2	June and December	4⅝	4½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13½	13 13½	4 8 11	" "	13⅝	13 1/16
15,000	10	6%	Do 6% Cumulative 2nd Pref.	11½ 12½	11½ 12½	4 16 0	" "	12 1/16	12
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	104 107	104 107	4 4 1	January and July ..	105¼	105⅛
58,000	5	1/0	United River Plate	1 2	1 2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	80 90	80 90	5 11 1	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
31,152	£10	..	City of London Electric Lighting (£6 paid)	6 6½	6 6½	..	..	6⅝	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..
8,332	£5	..	House to House Electric	..	..	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5¾ 6	5¾ 6¼	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5¾ 6	5¾ 6¼	..	January and July ..	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2⅝ 2¾	2⅝ 2¾	..	March	..	..
10,000	£5	3½%	Do. (fully paid)	4¾ 5	4¾ 5	..	March	..	..
111,000	5	..	London Electric Supply	..	1 1¼	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9 9½	8½ 9	..	..	9 1/16	8 13/16
6,318	10	..	Notting Hill Electric Lighting (fully paid)	5½ 6½	5 6	..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8½ 9	8¼ 8¾	..	..	8¾	8½
7,900	£5	7%	Do. 7% Preference	7¼ 7¾	7¼ 7¾	..	..	7 7/16	..
42,853	5	..	Westminster Electric Supply (fully paid)	6¾ 7¼	6¾ 6¾	..	..	6⅞	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES						
77,978	3	1/8	Brush Electrical Engineering	3¼ 3½	3¼ 3½	..	..	3⅝	3¼
69,996	2	6%	Do. 6 per Cent. Preference	2 2¼	2 2¼	5 7 7	..	2 1/16	2 1/16
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 6	5½ 6	5 16 8	January and July ..	..	..
17,139	5	17%	Edison and Swan United	..	..	..	..	..	..
45,000	10	12/0	Electric Construction	6 6½	5¾ 6¼	..	..	6¼	5¾
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅛ 3⅜	3¼ 3⅜	..	..	3⅜	3
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	22 23	21½ 22½	4 8 11	February & August	22⅜	22
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	March & September	104¼	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½ 4½	3¼ 4½	..	..	..	..
11,334	£10	8/0	Do. Preference	8 9	8 9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛ ⅜	⅛ ⅜	..	..	..	..
78,349	5	5/7½	Swan United (£3. 10s. paid)	3¼ 4	3⅞ 4¼	9 12 6	May and November	4	3⅞
36,250	12	12/0	Telegraph Construction and Maintenance	42 44	43 45	5 6 8	March and July.....	44½	43¾
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100 103	100 103	4 17 1	January and July .	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	..	1⅜ 1⅝	5 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid)	..	3½ 3¾	10 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	..	..	—	—	..	..
50,000	£10	—	City and South London Railway	2¼ 3¼	2¼ 3¼	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

The regulations which have been made by the County Council "with respect to the requirements for the protection from fire of theatres, houses, rooms, and other places of public resort," and which will be found elsewhere in our present issue, are very ambitious in their scope; but on the whole they ask for little that is unnecessary, and it is well to err on the safe side in such matters. Many structural regulations as to the details of the building have been in force for some years, and to these have been added from time to time many minor matters about locks and staircases. The rules for electric lighting are rather more detailed, but do not differ more from those which have been drawn up for ordinary work than is called for by the peculiar circumstances. As part of a specification for the fitting of a new theatre these regulations are excellent, but it is difficult to guess how far they are intended to be applied to existing houses. "Principal resistances shall be placed in a fire-proof room reserved for the purpose" is a good suggestion for the architect when engaged on designing a new building; but when every square foot of space under or near the stage is fully occupied, as is the case in nearly all theatres, nothing that can be called a "room" can be constructed without serious difficulty and expense.

It is directed that gas-engines shall be placed in rooms so adequately and continuously ventilated that no explosive mixture of gas can accumulate by any leakage through the engine, in the event of any of the gas-cocks being left turned on. This is practically forbidding the running of gas-engines in basement-rooms, and nothing short of an open shed would meet the conditions. A plan of the wiring is ordered to be kept always in a prominent position in the office of the manager of such premises. What is then to become of all the photographs, testimonials, and playbills? A plan of the wiring of an ordinary large house is complex enough, but the representation of the circuits which are constantly being altered in a well-equipped theatre would be enough to puzzle even a County Council inspector.

Like many of those who were present at Mr. Tesla's lectures, a correspondent who writes to us this week has been led to imagine that certain of his striking experiments are altogether new, while they really consist in repetitions of well-known effects on a large scale; and no one is better aware of this than Mr. Tesla himself. The glowing wires which excited so much interest were a reproduction, in a more brilliant style, of the experiment which was shown by Dr. Oliver Lodge at the Physical Society on June 12th last, and which was described on p. 200 of our last volume. Dr. Lodge's wire did not glow so brightly, it is true. He had a single wire about 60ft. long, and nothing more than a couple of Leyden jars and a Wimshurst machine were used. The length of the wire had been arranged to be in resonance, or syntony, with the jar, and thus distinct stationary waves were set up, part of the wire being dark and part bright. We are not aware whether Mr. Tesla has attempted to reproduce this interesting effect. The experiment with the concentric rings appeared to be more of the nature of a brush discharge. Our correspondent assumes that some appreciable current was passing, and that the space surrounding the conductor was "imbued with magnetism." It is doubtful whether in the majority of the experiments a single milliampere was used; and though Mr. Tesla has not yet proved that Prof. J. J. Thomson's experiments are not electro-magnetic, he seems justified, in the sense in which he uses the expression, in contending that all his own results are purely electrostatic.

It is as impossible to separate electro-magnetic phenomena from electrostatic, as to draw a line between kinetic and potential forms of energy. When the currents and potentials under investigation are steady, it is comparatively easy to distinguish between the electric and magnetic parts of the phenomena; but in electrical oscillations, such as Hertz, Tesla, and Thomson have worked with, the currents and potentials are constantly changing, and theory indicates that each electro-magnetic disturbance must then be accompanied by a corresponding electrostatic one at right angles to it, and *vice versa*. Since both kinds of disturbance must exist together with rapid oscillations, it is necessary, before any phenomenon can be called electrostatic, to know what is meant by the electrostatic effects being more important than the electro-magnetic ones. As far as we are aware, no one has yet clearly pointed this out.

The aurora borealis must, according to the common use of the terms, be electrostatic or electro-magnetic. It is more easy to theorize in a random fashion on the electrostatic hypothesis, and to talk about electrical discharges between cold and warm, or dry and moist, streams of air in the upper regions. It would not be difficult to account for

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the necessary volts; but the amperes, too, would have to be enormous to produce the magnetic disturbances which accompany these displays.

CONNECTED, no doubt, in some way which science has not yet discovered, with the huge spot which sailed across the disc of the sun this week, disappearing yesterday on the receding limb, and followed by a trail of four others, which may now be seen through a comfortable thickness of fog without a telescope, a magnificent aurora has been witnessed this week both in America and in Norway, and the telegraphic systems have been seriously affected. Powerful but unsteady currents of greater strength than the ordinary working currents interrupted the lines between New York and Albany for nearly two hours. An attempt to work a Wheatstone instrument on a line between Lyons and Paris on Saturday had to be given up. A sudden outburst occurred at about four o'clock on that afternoon, lasting about two hours, and an earth-current of 10 milli-amperes was recorded at Inverness, where the telegraphic business could only be carried on at intervals; and a renewal of the disturbance was observed at midnight.

THE blizzard, the fashionable name for a sharp snowstorm, has been attributed to the sun spots and the aurora. The Russian famine has already been accounted for and is a little out of phase, or this might be dragged in. The Bank rate, another matter which is supposed to be connected with solar activity, has as yet been unaffected.

IN a Note appearing in *Atti della Regia Accademia delle Scienze di Torino* Prof. GALILEO FERRARIS claims to have been the first to use the three-dynamometer method for the measurement of energy dissipated in hysteresis and eddy currents in transformers. In a Note presented to the same Academy on December 4, 1887, "*Sur la différence de phase des courants, sur le retard de l'induction, et sur la dissipation de l'energie dans les transformateurs*," the Professor showed methods of measuring not only the difference of phase between the primary and secondary currents, but also many important energy losses occurring in transformers. The three-dynamometer method for measuring difference of phase was first described by Mr. BLAKESLEY in *The Electrician* for October 2, 1885, and Prof. FERRARIS acknowledges priority in so far as this is concerned. He, however, says, "But Mr. BLAKESLEY's claim of priority only extends to the measurement of phase, and does not apply to the principal part of my work, the discussion of the results, and the numerous conclusions which I drew from them. Now two months after making this claim of priority (Physical Society, March 10th, 1888), and having thus knowledge of the existence of my work, Mr. T. H. BLAKESLEY at the meeting of the Physical Society, of May 12th, 1888, read a Note entitled 'Magnetic Lag,' in which he makes no allusion to my work, and re-establishes the same formula to which I had arrived. I should not have made any personal claim if my conclusions had not received important applications in the work of Professor AYRTON and Mr. J. F. TAYLOR (*Phil. Mag.*, 1891), and others, who in their memoirs have attributed to BLAKESLEY the formulæ which I established, and which are still true when the current is no longer sinusoidal, and is consequently intractable for purposes of calculation."

WHEN electric mining machinery was being discussed last year at the Institution of Civil Engineers, the only percussive drill that was described was an Ingersoll, driven by an ordinary electric motor. More than one speaker alluded to the electric reciprocating drills in use in America, and it was understood that these were fairly successful. The Marvin drill was described in our columns more than two years ago; and the Van Depoele drill, which was shown at the Frankfort Exhibition, was described and illustrated in the first number of the present volume. The electrical arrangements were very ingenious, and the theoretical difficulties of getting any reasonable efficiency from work done by a solenoidal magnet appeared to have been counterbalanced by the carefully considered mechanical details. But if the information given by the *Engineering and Mining Journal* of New York, which we reproduce in another column, is correct, these electric reciprocating drills have by no means fulfilled the promises which were made for them. It is true that the most serious defect which presents itself, viz., the heating of the solenoids and the piston, ought to be avoided to a great extent, if the arrangement is otherwise efficient, by proper lamination and insulation, while the mechanical difficulties are probably not more serious than those which have always to be met in striking out a new departure. It seems probable, however, that the coil and plunger principle is so inefficient as a motor that a very large current must be used to do the work, and that this is the cause of the trouble.

Telegraphic Communication with Fort Salisbury.—Telegraphic communication was on Wednesday finally established between Fort Salisbury and the Cape.

Proposed Teaching University for London.—The Privy Council have agreed to the proposed Teaching University for London being designated "The Gresham University."

Royal Society.—Among the Papers down for reading before the Royal Society yesterday was one by Lord Rayleigh, "On the Relative Densities of Hydrogen and Oxygen. No. II."

Bockenheim.—The town of Bockenheim has granted a concession for the supply of light and power by means of electricity for forty years to Lahmeyer and Co., of Frankfort-on-Main.

Glasgow.—Two members of the Gas and Electric Lighting Committee of the Corporation and three officials have been deputed to visit London to study street lighting by electricity.

Alternate-Current Motors.—The printing presses of the *Fremdenblatt*, says *Industries*, are now driven by means of alternate-current motors, current for which is obtained from the central station of the Internationale Electricitäts Gesellschaft.

"L'Elettricista."—We have received No. 1 of a new monthly electrical journal with this title, which is published in Rome under the direction of Signori F. Cardarelli, I. Brunelli, and A. Banti.

A Statue to Fresnel.—The Société Française de Physique are about to get up a subscription for the purpose of erecting a statue to Fresnel, and keeping his tomb at Père-Lachaise in repair.

Mr. Nikola Tesla.—Mr. Nikola Tesla will deliver a lecture this evening to the Société Française de Physique and the Société Internationale des Electriciens, in the hall of the Société d'Encouragement, at 44, Rue de Rennes, Paris.

The Waterloo-City Electric Railway.—The Lambeth Vestry have decided to oppose the Waterloo and City Railway

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Bill if the promoters do not insert a clause providing cheap fares for the working classes.

Liverpool.—At the last meeting of the Watch Committee it was finally decided to agree to the Liverpool Electric Supply Company's proposed Provisional Order upon the terms stated in our Notes column last week.

Hove.—An inquiry has just been held by the Local Government Board into the application of the Hove Commissioners for permission to borrow £1,400 for the purchase of land for the erection of an electric central station.

Hanley.—At a meeting of the Hanley Town Council, on Wednesday last, it was resolved to advertise for specifications and estimates of the cost of plant and distributing mains and machinery for lighting by electricity the area contained in the Hanley Provisional Order.

Leeds.—The managers of several of the leading banks, as well as the secretaries of some of the most important clubs and others, have issued a joint appeal to the Corporation asking that steps should be taken to secure for the town a supply of electricity at a reasonable rate.

Accumulator Cars in Rome.—An accumulator car is about to be tried in Rome. The motors and the accumulators are supplied by the Oerlikon Company, and it is proposed to commence a regular service of accumulator cars if satisfactory results are obtained with this first one.

The Telephone and the Post Office.—Dr. Cameron has given notice to call attention, on the Civil Service Estimates, to the relations between the Postal Telegraph Department and the telephone system. He will bring forward a motion in favour of the acquirement of the telephone system by the Post Office.

Useful Applications of Electricity.—Last week at the St. Paul, Shadwell, Mutual Improvement Association, Mr. W. H. Winny, A.I.E.E., delivered a lecture on the above subject. The lecture was illustrated by a number of experiments, and a hearty vote of thanks was passed to Mr. Winny for his demonstration.

St. Petersburg Electrical Exhibition.—A German paper states that in consequence of some defect in the conduits containing the electric light cables, it was not possible to switch on the current on January 23rd and 24th; and the Exhibition was, therefore, not opened on those days, involving a loss of some 3,000 roubles.

The Telephone Service of London.—We call attention to the fact that a special general meeting of members of the London Chamber of Commerce will be held at Botolph House, Eastcheap, on Monday next, at 2:30 p.m., for the purpose of discussing the general position of the commercial community in regard to the telephone service of London, and the Telephone Bills now before Parliament.

Electric Drilling.—We mentioned last week that Messrs. Bell Bros., of Middlesborough, were about to adopt electricity as a means of transmitting power to drills in their Cleveland ironstone mines. This work is being carried out by Messrs. D. Selby Bigge and Co., of Newcastle-on-Tyne, who have done much to advance electric mining in that district, several power plants having been recently installed by them.

The Cork Gas Company and the Electric Light.—At the meeting of the shareholders of the Cork Gas Consumers' Company yesterday it was announced that the Corporation, without giving any reasons, had refused their assent to the Company's Electric Lighting Order. Although such assent is not legally necessary, the Directors have deemed it wiser for the present not to take any further steps to obtain an order in the present Session of Parliament.

The Brighton and Hove Electric Lighting Company.—This company has issued a circular setting forth the history of the undertaking and detailing the treatment it has met with at the hands of the Town Council, the Board of Trade, and the Local Government Board. A clearer case for just if not generous dealing was never made out; and it is most difficult, especially when we remember that the whole local press has supported this view, to understand why the Town Council should have acted otherwise than fairly.

Coast Lights.—In answer to some questions addressed to him in the House of Commons last week, Sir Michael Hicks-Beach stated that he had been in communication with the Trinity House, who stated that whether the Wigham light at Tory Island was more effective in fog could only be estimated from the results of experiments at South Foreland, which were conclusively in favour of the electric light. Experiments in sky flashing, so far as they had gone, had not been encouraging for the adoption of that system. The Elder Brethren were in communication with the Shipmasters' Society on the subject.

The Weight of Incandescent Lamps.—In view of the tax now imposed on all incandescent lamps imported into France, the following figures from *L'Industrie Electrique* are of interest:—

One hundred 100-volt c.p. Lamps.

	Weight. (kilogrammes).	Duty (francs.) Ordinary.	Minimum.
Fitted with eyelets	1·7	13·6	11·9
Fitted with copper bases	2·8	11·2	9·8
Fitted with vitrite sockets	3·4	13·6	11·9

A complete list of electrical articles affected by the new tariff appeared in our issue of January 22nd.

Southport.—At the last meeting of the Town Council the Foreshore and Improvement Committee was authorised to purchase an electric launch for use on the new marine lake. The electric lighting sub-committee recommended the rescinding of a resolution providing, amongst other things, that the Southport Electric Lighting Order, 1891, be put into force by the Corporation, without delegating the powers thereby conferred to a private Company. It was resolved that this portion of the resolution be rescinded, and that a circular be issued to all householders in the scheduled area asking them if they intend to light their premises with the electric light.

The Magnetic Properties of Oxygen.—Commenting on Prof. Dewar's recent experimental verification of the magnetic properties possessed by liquid oxygen, M. Guillaume points out in *L'Industrie Electrique* that if we accept the values found by Edmond Becquerel for the magnetic constant of oxygen, it ought, when in the liquid state, and in a field of medium strength, to possess a magnetic moment per cubic centimetre, one-third of that of iron, and a magnetic moment per gramme twice as great as that of iron; so that the strange conclusion is forced upon us that oxygen is the most magnetic of substances. M. Guillaume also points out that liquid oxygen might be made to give a faithful and delicate representation of the distribution of the lines of force in a magnetic field, the liquid being heaped up in the strong places.

The Electric Railway Schemes.—Mr. Whitmore has given notice of his intention to move:—"That a Joint Committee of Lords and Commons be appointed to consider the best method of dealing with the electric and cable railway schemes proposed to be sanctioned within the limits of the metropolis by Bills introduced, or to be introduced, in the present Session, and to report their opinion as to whether underground railways worked by electricity or cable traction are calculated to afford sufficient accommodation for the present and probable future traffic; as to whether any, and which, of the schemes propose satisfactory lines of route; as to the terms and conditions under which the subsoil should be appropriated; whether any, and, if any, what, schemes should be proceeded with during the present Session. That a message be sent to the Lords to communicate this resolution, and desire their concurrence."

Continuous-Current Transmission of Power.—Le Compagnie de l'Industrie Electrique Genève have just erected an interesting electric transmission of power plant in the neighbourhood of Genoa. Constant-current motors are employed, the largest of which absorbs 1,000 volts, or 50 kilowatts, the current being about 50 amperes. The source of power is 30 kilometres distant from Genoa, but the first motor is only 8 kilometres from the turbine station. When all the dynamos are at work the pressure amounts to 3,000 volts; it will soon be 6,000 volts; and a maximum of 8,000 volts is contemplated. Carbon brushes are employed, and give every satisfaction. Three stations will ultimately be at work, but only one is now in operation. The first station is 2,000ft. above the town of

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Genoa, water-power being obtained from the artificial lake which acts as a reservoir to the town supply; there is a water storage of 4,000,000 cubic metres (880×10^6 gallons). The second station is 400ft. below No. 1. Here there are four 140-H.P. Faesch-Piccard turbines, each driving a pair of 70-H.P. 1,000-volt dynamos, coupled in series. The third station is some 460ft. below No. 2, and the plant comprises one 140-H.P. turbine and two 300-H.P. turbines. The 140-H.P. turbine drives two 70-H.P. 1,000-volt dynamos. There are three circuits of 9mm. wire, each supplied by a separate station.

Bradford.—We were unable last week to accept as accurate the *Bradford Observer's* report of Mr. Alderman Priestman's remarks with reference to the cost of coal at the municipal central station. In the original report it was stated that "the cost of coal per Board of Trade unit had been 12·58d." To find what this figure actually meant we took Mr. Alderman Priestman's figures for coal consumed (865 tons) for price per ton (7s. 7d.) and for units sold (154,431) as correct, and worked out the cost of coal per Board of Trade unit at ·58d., and the coal consumed per Board of Trade unit at 14½lb. The passage, we are authoritatively informed, should read as follows:—"The coal which had been consumed during the half-year, without reckoning the stocks at the beginning and end, which were about the same, was 867¼ tons, or 1,942,640lb. The total cost of the coal had been £342, and when he reckoned the number of Board of Trade units sold, which were 154,431, he found that *the consumption of coal per Board of Trade unit had been 12·58lb.*, not 30 and 34lbs., as he had heard it stated outside that building. He believed it was usually admitted that a Board of Trade unit required between 1½ to 2 indicated horse-power to generate; and so, if the matter was reckoned out, it would very soon be found what had been the number of pounds per horse-power that had been consumed. The average price of coal—and this was a very important thing to take into account—had only been 7s. 10½d. delivered at the works."

Obituary.—The death is announced on January 2nd of Prof. Shida Rinzaburo, of the College of Engineering in the Imperial University of Japan, and formerly Director of the Engineering Bureau in the Department of Communications. Twelve years ago Prof. Shida, with a band of fellow graduates of the Imperial College of Engineering, sailed for Europe to prosecute studies in physical science. Three of the band attended Sir William Thomson's classes at Glasgow University. Prof. Shida scored a brilliant success by securing the first place in the Natural Philosophy and Higher Mathematics classes, and impressed Sir William with a high opinion of his powers. His Paper on the "Magnetic Susceptibility of Iron" secured a gold medal from the Royal Society. During the seven or eight years of active life that were vouchsafed to Prof. Shida, he did notable work in the University, in the capital, and in the provinces; and perhaps to him more than any other is due the credit of bringing the telegraphic system of Japan to its present state of efficiency. An energetic member of the leading scientific societies of Tokyo, President of Council of the Electrical Society, a brilliant lecturer, and original investigator, his loss will be severely felt. Born 35 years ago in the province of Saga, Prof. Shida entered the Imperial College of Engineering in the year 1874, and had a successful course as a student. For some time back he had been suffering from consumption, which developed very rapidly at the close, so that his death came as an unexpected shock to his many friends.——The death is also announced of Dr. T A. Hirst, F.R.S. Dr. Hirst was born in 1830, and early in life made the acquaintance of Prof. Tyndall. In 1861 he was elected a Fellow of the Royal Society. He was also one of the original members of the London Mathematical Society, which was founded in 1864, under the presidentship of Prof. De Morgan. In 1865 Dr. Hirst was appointed Professor of Mathematical Physics in University College, London, which chair he held until 1867, when he succeeded De Morgan as Professor of Mathematics in that College. In 1870 he accepted the newly-created appointment of Assistant-Registrar in the University of London. Early in 1873, when the Royal Naval College was founded at Greenwich, he became director of studies, and held the post for ten years. Dr. Hirst was three times a member of the Council of the Royal Society, and twice one of its vice-presidents. In 1883 one of the Royal medals was awarded to him. He was also a Fellow of the Royal Astronomical Society, a member of the Physical Society, an *ex officio* member of the Council of the British Association. He served for some years on the Council of University College, London, and in 1882 was made a Fellow of the University of London.——Major-General Ryrie Alexander, who for the past three years has acted as chairman for Messrs. Shippey Brothers (Limited), and who was connected with several other electrical companies, died on the 10th inst., at his residence, Redwall, Dartmouth, Devon.——The death is announced of Prof. William Dittmar, F.R.S., Professor of Chemistry at the Glasgow and West of Scotland Technical College.

The Chicago Exhibition.—We have received the following communication from the Electrical Committee of the Royal Commission for the Chicago Exhibition, 1893:—

The Electrical Committee are anxious that the Electrical Department of the Exhibition should contain a good representation from this country. The British exhibit will include a historical collection as well as the contributions which will be sent in by commercial firms. In addition, it is hoped that a portion of the electric lighting of the Exhibition may be carried out by some British firms, and the Committee think that the arrangements of a complete lighting station on the English method could advantageously be shown at Chicago. From the English point of view it is specially desirable to show how large a share English electricians have had in developing electrical science and its practical applications. The first electrician was an Englishman, Gilbert. It was in England that a practical telegraph line was first worked out by Ronalds in 1816. There are no names more closely associated with the early development of the science of electricity than those of Davy and Faraday. The introduction of telegraphy must inseparably be connected with Cooke and Wheatstone; while the early history of the dynamo would be incomplete indeed without reference to Wylde and Holmes. In England, electricity was first applied to the working of railways, and here nearly all the submarine cables of the world are made. It is hoped that arrangements may be made for showing the fine collection of historical apparatus in the possession of the Post Office, and this will be supplemented by contributions which will be sought from many other sources.

On the commercial side, while there is no disputing that practical electric lighting has made greater progress in America than in this country, there is yet much that England can show electricians on the other side of the Atlantic. The domestic uses of electricity and its artistic application are matters in which they confess themselves to be less advanced than we are, and probably many firms who make this a speciality will find it to their interest to show in the Exhibition electrical fittings and the manner of their application. It is especially to be remembered that the Exhibition will be visited by numbers of foreigners, and especially by many persons from our own colonies; and it is important that English electricians should not miss this opportunity of strengthening and increasing their hold on colonial trade, since it is quite certain that a strenuous effort will be made by American manufacturers to get this important source of revenue into their own hands. Another department in which the United States exhibit will certainly be deficient is that of electric railway signals. The methods on which American railways are worked do not, as is well known, require the very complete system of signalling apparatus employed in European countries; but this system is now being introduced into America, and will probably supplant the methods now in use. There is, therefore, a very favourable opportunity for manufacturers of this class of apparatus to bring themselves before the notice of American customers. Another important department which ought not to be neglected is that of electro-metallurgy. Here also English inventors will probably find it to their advantage to bring their inventions under the notice of American metallurgists. A special building in Jackson Park will be devoted to the electrical exhibits. The size of this building is 700ft. by 350ft., enclosing an area of 250,000 square feet. The space provisionally allotted to Great Britain in the building is 20,000ft. It is understood that all the buildings as well as the grounds, will be lighted at night. Applications for space in the British Section must be made upon forms to be obtained from the Secretary of the Commission, Sir Henry Trueman Wood, at the Society of Arts, John-street, Adelphi, London, W.C. They must be sent in, properly filled up, not later than February 29, 1892, and addressed to the Secretary, as above. —Yours faithfully, W. H. PREECE, Chairman of the Committee.

The Electrical Committee consists of:—Mr. W. H. Preece, the Attorney-General, Sir Frederick Bramwell, Sir Frederick Abel, Prof. W. Grylls Adams, Colonel R. T. Armstrong, Prof. W. E. Ayrton, Major Cardew, Mr. Latimer Clark, Mr. R. E. B. Crompton, Prof. W. Crookes, Prof. Dewar, Prof. Ewing, Major-General E. R. Festing, Prof. Forbes, Prof. Carey Foster, Mr. Edward Graves, Mr. Matthew Gray, Dr. John Hopkinson, Prof. Hughes, Mr. Gisbert Kapp, Mr. J. C. Lamb, Mr. William Mather, Mr. W. M. Mordey, Mr. Fletcher Moulton, Hon. Charles Parsons, Prof. Perry, Lord Rayleigh, Mr. Alexander Siemens, Mr. C. E. Spagnoletti, Prof. Silvanus Thompson, Prof. J. J. Thomson, Sir William Thomson, Major-General C. E. Webber, and Mr. Willans.

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VIEWS OF ETHER WAVES AND THEIR ACTION.

BY S. TOLVER PRESTON.

There is probably nothing essentially new in the following ideas; but the point of view taken may commend itself as of practical utility for purposes of illustration.

We are well acquainted with stationary (or fixed) magnetic fields, *i.e.*, with their properties, also with rotating* magnetic fields, exemplified by the late three-phase motors. *Translated* magnetic fields, of course, show themselves when magnets or currents carrying conductors are translated. When the *electro-magnetic* theory of light is spoken of, many have, perhaps, not so clear a grasp of the nature or properties of the waves as they have of fixed magnetic fields.

May it not be simple to view waves of light and the larger waves accompanying ordinary alternating currents (in sum *all* ether waves) as travelling magnetic (*i.e.*, self-translated) fields? By "travelling magnetic fields" is meant magnetic fields (successively positive and negative) endowed with a translatory motion equal to that of light.

We may neglect, as a preliminary, the "electric displacement" or electrostatic component of the wave (situated at right angles to the magnetic), as it does not alter the principle of what we are considering; or, if we wish, of course it can be taken into account.

In this case effects precisely the same in kind would be produced as if the magnetic fields—such they really are constituting the waves—were fixed, and (conversely) objects were themselves translated with adequate velocity through these magnetic fields. This view is admittedly rough, but such conceptions are often the most useful in getting a rough-hewn image of the truth (so to speak); so that a just view of the inductive effects *in kind* may be obtained without pretending to minute accuracy as to subordinate detail. *Any* ether wave (including a wave of light) may then be regarded as consisting substantially of two contiguous—positive and negative—magnetic fields, which instead of being fixed as ordinary magnetic fields about magnets or (continuous) currents, are travelling with the velocity of light through the ether. In estimating roughly the inductive effects of light and of ether waves of whatever length, we have then only to consider those which would be produced if bodies (conducting and otherwise) were translated with adequate speed through a succession of fixed magnetic fields, alternately positive and negative. To translate bodies at the speed of light is, of course, as impracticable an achievement as the manufacture of a Carnot heat-engine; but the mode of illustration chosen may be none the less of value.

For rough illustration, a succession of fixed magnetic fields alternately positive and negative may be supposed produced by a double row of horseshoe electro-magnets, with poles facing each other, and an interval between (to allow conductors to pass across the fields), so that the magnetic fields between the opposed poles are alternately of opposite sign. Of course these fields are partly renewed (when weakened by conductors striking across the fields), at the expense of the current of the electro-magnet coils. This is not the fact with the travelling (self-translated) fields of electro-magnetic waves, although each weakened wave is immediately supplied by another. It is, it appears, an instance of difference of degree rather than of *kind* between the two cases.

For it appears, we may say, that a magnetic field can (1) either be translated with a magnet or current, or (2) it has the power, under certain conditions, of self translation (with the velocity of light) through space, when left to itself. The practical point we may lay stress on is, that whether a magnetic field translates itself (through the ether) as part of an electro-magnetic wave, or is translated in connection with a moving magnet or current, an effect substantially the same in kind as produced on conductors which the field crosses. Some practical advantage may be found in the above mode of illustration. We may note, then, that all "induction" is due to magnetic fields crossing bodies, whether these fields be carried by magnets or currents, or carry themselves, as they do in the case of waves of heat and light, waves accompanying alternate-current machines, &c.; in brief, waves of any length generated in ether, which (waves) are all the same in constitution, all consisting of travelling magnetic fields (alternately inverse).

When an alternating current is sent through a bobbin or coil of wire, it has been recently shown that it will repel a disc or ring of copper (some pounds in weight) which may even be made to float in the air, as it were, and prevented from receding, by strings; as was illustrated in *The Electrician*, March 13, 1891, p. 570. This experiment may be regarded as exemplifying also the repulsion of light, which consists equally of travelling magnetic fields, as in the above case (of the magnetic coil) only more quickly alternating. The repulsion of light or radiant heat at the sun's surface (or rather its reaction against the emitting sun) is calculably 27 grains per square foot of area. From this the total reaction against the sun due to its own radiation may be readily calculated to be 109 billion tons.*

Few realise probably that when, by the sun's agency and a "burning-glass," a hole is burnt in some substance, this is effected by the impinging of a succession of magnetic fields moving at the velocity of light, and throwing the parts (or pervading ether) of the substance into resonance, like a small-scale Hertz resonator; and with such energy that the substance is disintegrated by the alternating electric currents, which, on molecular scale, probably *themselves constitute the heat*. For we have rhythmical heat and non-rhythmical heat. The former motion seems to be an alternating electric current, which is confirmed by the fact that *electro-magnetic* waves are generated by this rhythmical motion of heat. The second form of heat, *non*-rhythmical, is quite different (perfectly irregular)—incompetent to generate waves.

Prof. Lodge, to whom many are indebted for his articles, "Modern Views of Electricity,"† expresses the view that "light is an electrical disturbance, and light waves are excited by electric oscillations" (p. 418). If this be true, of course the motion which generates *heat* waves must equally be an electrical disturbance. In further accord with this, Prof. Lodge mentions in the same article that "those short ethereal waves which are able to affect the retina, and which we are accustomed to call 'light,' may be really excited by electrical oscillations or surgings in circuits of atomic dimensions" (p. 417). But in the last of the series of articles (*Nature*, January 31, 1889) we have the remark, viz., "Light, when it falls on a conductor, excites first electric currents and then heat" (p. 321).

Assuming, of course, the "conductor" to be solid in the absence of specification, then it seems a question here whether *two* effects are excited. For the molecules of a solid, being incapable of free translatory motion, would scarcely, probably, take up that irregular *non*-rhythmical movement of heat which is the additional characteristic of liquids and gases. The rhythmical form of heat which "radiates" would doubtless alone be developed in the "conductor" on which the "light falls." If so, we have not *first* electric currents and *then* heat excited by the light, but only electric currents, which *are*, however, what we call "heat," *i.e.*, of the rhythmical kind which generate waves (viz., electro-magnetic waves which are waves of heat when short enough). The "conductor" on which the "light falls" becomes a Hertz resonator on a small scale, emitting electro-magnetic waves of the same period‡ as those which fall on it. It may even be a question whether, with an (ordinary) large-scale Hertz resonator, the so-called "heat" which accompanies the resonance may not be looked at simply as a sort of higher harmonic of the big-scale resonance, and which (small-scale resonance) also limits electro-magnetic waves. Returning for a moment to our illustration of the sun and burning-glass, suppose that, instead of impinging on a combustible substance, the magnetic fields impinge on a sheet of bright

* In regard to the particular case where a magnet rotates on its own axis, reference may be made to a Paper published by me in the *Phil. Mag.*, Feb., 1891; also other Papers, *Phil. Mag.*, Feb. and March, 1885.

* Reference may here be made to my former article in *The Electrician*, Sept. 18, 1891, "The Ether as a Power Transmitter."

† *Nature*, Aug. 30, 1888. Also now published separately as a volume, with appendices.

‡ Waves of obscure heat and waves of various periods ordinarily accompany light, of course.

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silver; then disintegration is not produced by the resonance as before; but the opposing (outgoing) magnetic fields accompanying the resonance may be energetic enough to repel the entering fields, and produce nearly perfect reflection. May we not regard the reflection of light from a metal as due to the interaction or repulsion of opposing magnetic fields?

Hamburg, December, 1891.

NOTES ON SUBMARINE CABLE WORK.

BY H. D. WILKINSON.

(*Continued from page 381.*)

THE CABLE SHIP ON REPAIRS.

1. **Speaking Apparatus.**—The position of a fault having been determined by a selection of tests the cable ship proceeds to this position, first leaving instructions upon what day and time the terminal stations are to commence keeping watch for her. When the insulation of the land line between the office

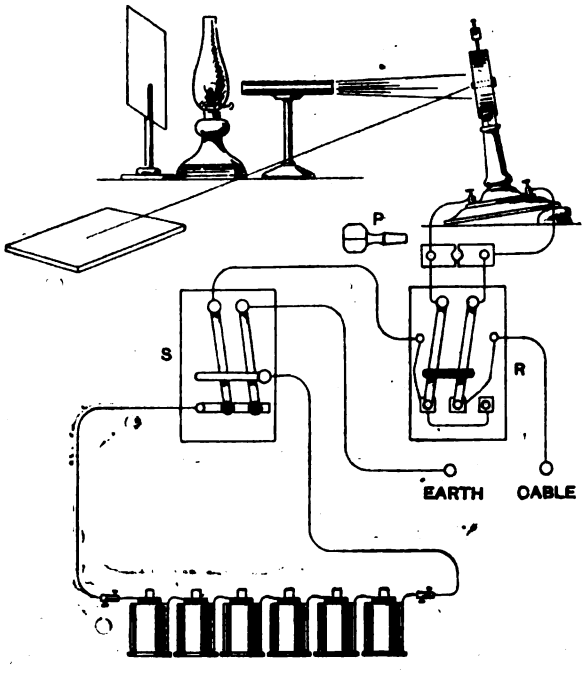

FIG. 1.—Speaking Connections.

and cable-house is perfect, watch is usually kept in the office on the syphon recorder instrument, this being most convenient; but if it is at all low the ship will not be satisfied with testing through it, and watch has to be kept at the cable-house, where the shore end of the cable is landed. In such cases a set of speaking apparatus, precisely similar to that on board ship, and usually kept at the cable-house, is connected up, as in Fig. 1. A battery of Minotti cells, in the proportion of one cell, at most, to 120 miles of cable, is joined up to the sending key S, as shown, the conductor or line of the cable is connected through the mirror instrument to one side of this key, the other side of the same being connected to the earth return of the cable. The outside sheathing of galvanised iron which protects the cable is used as the earth return. It may be mentioned in passing that the ends of cables as they are landed are, in some cases, passed through packed glands in a cast-iron joint box, and therein jointed on to insulated wires leading to the cable-house in wrought-iron pipes containing water. In this system, which is the most protective, the pipes are laid in a trench, and the joint box sunk at low-water mark. The galvanised sheathing of each cable is jointed in the box to a separate insulated wire, which is labelled in the cable-house as the earth belonging to that particular cable. In a similar manner when the cables are landed direct into the cable-house joints are made to the sheathing wires of each cable, and kept distinct as their own individual earths. It is found that unless this is done there is interference between the currents in different cables.

It is usual to fit up a small terminal board in the cable-house and bring the cables and their earths to it, where they can be joined on to the terminals of the land lines leading to the office. It is therefore a simple matter when watch for the ship is to be kept at the cable-houses to disconnect the required cable and its earth from the pair of land-line terminals to which they are joined, and connect them to the speaking apparatus as shown. A beam of light is thrown on to the mirror instrument by means of an oil lamp and lense. The latter is fixed at one end of a horizontal brass tube, and the tube is shifted until a good sharp reflected ray from the mirror is obtained. The light of the lamp should then be shielded from the eyes by a paper screen, or the lamp for this purpose may be placed in a wooden box without top. The reflected ray can either be directed horizontally so as to throw an image on a vertical white screen or the wall, or it may be directed downwards by tilting the mirror instrument as shown. For keeping watch for the ship the light should be projected on to a vertical screen, as it can then be seen from all parts of the room. The manner of titling the mirror to throw the light on the message pad, as shown in the figure, has come very generally into use where lines are worked by this instrument, the operator reading and writing down the message himself at the same time without the aid of a writer.

The mirror instrument is provided with a short-circuit piece P, which is plugged in when sending. This is a better arrangement than a two-way switch for sending and receiving, because the mirror can be proved occasionally with the sending key.

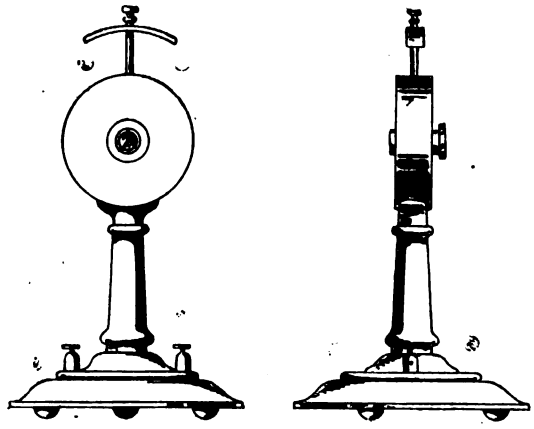

FIG. 2.—Speaking Mirror,

A reversing switch R, for reversing the signals received on the mirror, is very convenient. If the signals from the ship are reversed, all that has to be done is to turn this switch the other way. The connections of this switch are marked on the diagram, and will be easily understood. Another way of reversing the signals is to twist the tube round in which the mirror is suspended, so reversing the position of the poles of the magnet on the mirror; but this is not always a speedy way of doing it, as the controlling magnet and lense may want re-adjusting. Another way is to reverse the wires connected to the mirror instrument; but with a little practice reversed signals can be read with perfect ease, necessitating no change whatever.

In the ship's signalling connections there is generally fitted a battery commutator for changing the number of cells rapidly, to suit any length or condition of cable; but, in order to avoid delay, it is advisable to connect a shunt resistance to the mirror-instrument, which can be rapidly adjusted to make the signals a readable size directly the ship is observed calling. The wire connecting the shunt resistance to the mirror should be disconnected before the ship calls, so that the instrument is in its most sensitive state.

The mirror instrument introduced by Sir William Thomson, holds its own for simplicity against any other telegraph instrument. Although now entirely supplanted on important lines

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by the syphon recorder, its use is still largely maintained. Every station has its speaking mirror to fall back on in case of one or more of the recorders failing, and its mirror for cable-house use; while on board ship it is invariably used for speaking with the shore. The instrument is a great favourite with old cable operators, and there is certainly a fascination about the noiseless movement of the spot of light, which the recorder with its revolving mouse mill cannot lay claim to. This instrument is represented in Fig. 2, and consists simply of a coil wound to a resistance of 700 to 1,000 ohms, mounted on a wooden stand. The mirror is suspended at one end of a brass tube (Fig. 3), fitting loosely into the centre of the coil, and the front cheek of the coil is splayed out to prevent interception of the reflected ray. The signals are much improved by introducing a soft iron core within the tube. The core becomes magnetised by every current received through the coil, and therefore produces greater amplitude in the signals,

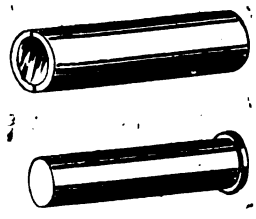

Fig. 3.—Tube and Mirror and Iron Core.

while, owing to the fact that it does not give up or reverse its magnetism as rapidly as the signalling currents pass through the coil, the signals are steadied and rounded off, a considerable advantage on short lines. This improvement was introduced by Mr. Walter Judd, of the Eastern Extension Telegraph Company, and has been found to lessen the interference of earth currents on signals. The core has a shoulder at one end to prevent it touching the mirror by entering too far in the tube, while, by adjusting the length of core within the tube the signals can be brought to any required size.

The suspension silk need not be a single fibre, but the thickness can be suited to the sensitiveness required. The silk is best fastened on by laying the mirror face downwards on a table or flat board as at M (Fig. 4), one end of the silk having been fastened down to the board by a little beeswax at A, while the other end is held in the left hand. The silk can then be held taut and slightly raised, while the mirror is shifted round so as to bring the magnet in a position at right angles to the

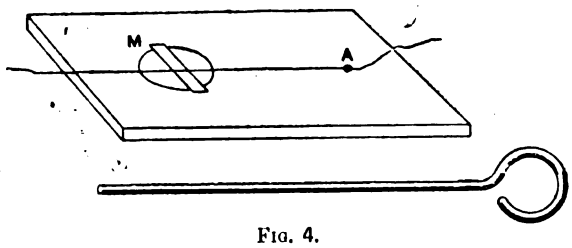

Fig. 4.

silk. By means of a light copper rod (Fig. 4) heated at the end in a spirit flame, a little melted beeswax or shellac is applied to the back of the mirror to fasten the silk down. The wax should cover the silk close up to the edge of the mirror, but not be allowed to run into the silk beyond, or it will stiffen the fibre where it should be perfectly free.

Another mode of suspending the mirror is shown in Fig. 5. To a light brass frame, with a disc, D, rigidly fixed at one end, is fixed a spring, S, and a sliding piece, P. The lower end of the silk suspension is attached to the end of the spring, and its upper end is passed over a projection on the disc, and attached to the pin A. This pin has a screw-threaded shank, which passes through a clear hole in the sliding piece P, and its position can be regulated by a nut on the shank of the pin without twisting the silk. This provides one means of adjustment, while the sliding piece P can be shifted so as to regulate the tension on the silk to any required extent, and finally fastened in position by the set screw. The spring engages in a slot in the disc, preventing it from being raised too high and decentralising the mirror. The whole, when completed and adjusted, is slipped into a brass tube, B, provided with a glass window at the end near the mirror. The tube is then slipped into the coil of the instrument. It is remarkable that the mirror-speaking instrument is so sensitive to cable signals when the suspension fibre is fastened top and bottom, and there is only about

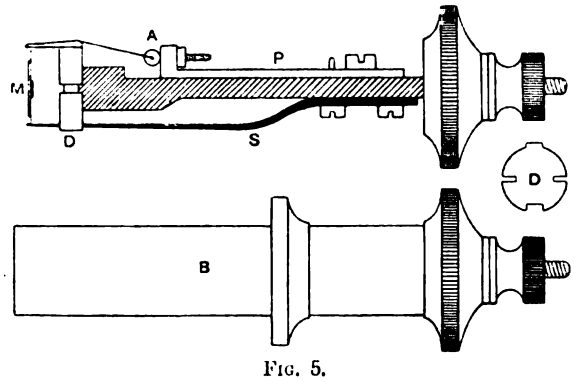

Fig. 5.

one-sixteenth of an inch of fibre above and below the mirror free to turn. The first experiments were with long fibres; but soon after the completion of the 1866 Atlantic Cable Mr. Graves, the superintendent at Valentia station, together with Mr. T. E. Weatherall, carried out a series of experiments starting with fibres 2in. long each side of the mirror, and found that the instrument retained its sensitiveness as they reduced the length of fibre step by step till a length of only $\frac{1}{16}$in. was found to be necessary for good sharp signals.

(To be continued.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, February 19th.

3 p.m. Inauguration of the "William Siemens" Electrical Laboratory, at King's College. By Sir William Thomson, P.R.S.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Micro-Organisms in their relation to Chemical Change." By Prof. Percy F. Frankland, F.R.S.

SATURDAY, February 20th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Matter at Rest and in Motion." By Lord Rayleigh, F.R.S.

MONDAY, February 22nd.

LONDON CHAMBER OF COMMERCE.

2.30 p.m. Special General Meeting at Botolph House, Eastcheap: "To consider the general position of the Commercial Community in regard to the Telephone Service of London and the Telephone Bills now before Parliament." Sir A. K. Rollit, M.P., in the Chair.

TUESDAY, February 23rd.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Papers to be read with a view to discussion: (1) "The Bishop Rock Lighthouses." By W. T. Douglass, M.Inst. C.E. (2) "The Illumination by Gas of Tory Island Lighthouse, Co. Donegal." By David C. Salmond, Assoc.M.Inst.C.E. The Meeting will be adjourned at 9 p.m., when the President and Council will hold a Reception in the Libraries.

WEDNESDAY, February 24th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Ancient and Modern Art Pottery of Japan." By Ernest Hart.

THURSDAY, February 25th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting.

FRIDAY, February 26th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "On Modes of representing Electromotive Forces and Currents in Diagrams." By Prof. S. P. Thompson, F.R.S. (2) "On the Flexure of Long Pillars under their own Weight." By Prof. Maurice FitzGerald, M.B. (3) "On Choking Coils." By Prof. J. Perry, F.R.S.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Optical Projection." By Sir David Salomons, M.A.

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ERRORS IN TELEGRAMS.

The epidemic of correspondence relating to the shortcomings and misdeeds of the telegraph service has, this winter, been of unusual length and severity. If to err is human—and the telegraph is very human in that respect—to grumble is also human; and when free outlet for it is offered in the daily newspapers, no wonder the grumblers grow more numerous every year. For telegraphic errors, following the law of averages like other things, increase with the increase of telegrams, although their relative proportion may remain unaltered. We all have our experience of blunders in telegrams, and know how exasperating they are; but we know too that we get many more telegrams than we did formerly when they were much dearer, and not free from error even then. Still the fact is none the less vexatious that telegrams are shockingly mutilated at times, and that minor and trifling errors are as common as flies in treacle. We are therefore not sorry to see this long string of complaints made public; for it will have the effect, no doubt, of reducing some of the avoidable errors, which, if of no great importance, cast discredit on the administration. This class of error, we often suspect, is due to slovenly writing in the offices, and to the absence of a little common sense. These are defects that might be remedied. Then, again, the speed of signalling is said to be a fruitful source of error. In one of the very few letters published on "the other side" a telegraphist complained that the sending was generally too fast—meaning faster than the receiving

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operator can read correctly. If this is true to any great extent probably some check could be put upon a practice so risky, even though the public would lose something in the way of speed. Complaints on the score of delay are comparatively rare. Perhaps there would be none the more if the signalling were a little slower.

As regards unavoidable or venial errors, they are largely attributable, on the one hand, to electrical or mechanical failures, and on the other to misreadings of the text. Of the former it would seem that everything has been done that ingenuity, science and money can do to make the appliances and wires as perfect as they are capable of being. But they have their weak points at the best, and become less and less reliable as the high speeds are increased. And this is true, also, of the human part of the machinery; for there is, no doubt, a rate of working beyond which the eyes and ears and hands cannot be always trusted. The public have got their cheap telegrams, and in such abundance that they must be despatched with dangerous rapidity. The public ought to be tolerant, therefore, of mistakes due to these causes. Misreading of the text is more often the senders' fault than the operators'. If the public would give themselves the trouble to write legibly, and word their messages with some regard to the possibilities of their being misunderstood, there would be very few complaints under this head. Business firms do attend to these matters, and are sending telegrams all the day long; but the general public do not, and in the aggregate they probably send most of the telegrams that occupy the wires. Anybody who has experience of how the general public use their pens can form some idea of what the telegraphist has to decipher in the way of handwriting, and this when the signalling is being done at top speed. As often as not the context gives no more clue to the meaning than the coded words of a cablegram; for your general public have learnt how to cut down their missives to the scrappiest and most disjointed sixpennyworth possible, with the result that unless it is written plainly, which is seldom the case, it is sure to be signalled wrongly.

The class of persons just referred to were foremost among the complainants in the newspapers; indeed, we do not remember seeing the signatures of any business firms, although individually they send and receive by far the greatest number of telegrams. This fact would seem to support our view that compared with the gross number of messages, the mistakes in them are not extravagantly numerous. Business men, however, have the advantage of corresponding with business places, where, of course, there are appliances and operators of a first-rate order. Obviously this is not the case everywhere, and never can be the case. The non-business part of the community, whose miscellaneous telegrams are destined for suburban villas, small provincial towns, and country villages, far from the madding crowd, have therefore to put up with an inferior service. Nobody can reasonably complain of this, unless it be the Post Office itself, who, by stress of public demands, have had to extend the system far beyond its paying capacity, and, for other reasons, far beyond the possibilities of maintaining a uniformly high efficiency. Good telegraphists are made by large experience—experience which cannot be had in the minor offices of the service.

There remain only those errors which are due to the operators themselves, whether experienced or inexperienced. The best of them blunder, oftener, probably, than we hear of. So far as we know there is no check upon them, except public complaints; and as all recording instruments have gone out of fashion it is no longer possible to fix the blame upon the offending party. This is one of the evils attendant upon high speeds of signalling, necessitated by the enormous increase of work. When the tariff was about to be cheapened to sixpence we predicted that though it would be nicer for the pockets of senders it would be nastier for their telegrams. The only remedy possible would be a vast augmentation of the number of wires, and a general slowing down of the signalling; but this would be far from nice for the pockets of the taxpayer. On the whole, therefore, we are inclined to think that the benefits of a cheap system of telegraphy must be accepted as a set-off against the inherent defects of such a system, except as regards those imperfections which careful supervision can cure. The public may not accept this view of the case, but in more ways than one they have a remedy in their own hands. The *Standard* tells them that their telegrams are always of vital importance, and that nobody is so foolish as to spend sixpence when the matter is not urgent. It would be just as true to say that nobody takes a penny omnibus who can walk, or that nobody would spend sixpence upon a drink unless dying of thirst. The *Standard's* statement is ludicrously wrong. If all telegrams were withheld that could be just as easily served by letter or by hand, the pressure on the wires would be appreciably diminished. For the rest, if the senders would take a little more pains themselves, they would have much less cause to complain of the telegraphists.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(Continued from page 348.)

§ 62. **General Considerations.**—In practical electrical science we meet with many quantities of widely varying natures, such as capacities of condensers, coefficients of self and mutual induction, resistances of coils, and so on; and we frequently desire to know the values of these quantities in terms of some units which are known and recognised by other experimenters. The progress of electrical science, and the recognition and appreciation of the great principle of the conservation of energy, have led electricians to understand that all electrical quantities can be ultimately referred to the units of length, mass, and time. When once the connections between electrical and dynamical quantities have been clearly perceived, and it has been determined to work upon a system of derived units which introduces the smallest possible number of numerical factors into the equations, we are no longer free in our choice of electrical units. (*See* § 3.) There are two alternatives before us. We may *either* have a free choice of electrical "standards," and, for instance, define the unit of resistance as that of a metre of mercury of one square millimetre section, and the unit of E.M.F. as that of a standard Clark cell; *or* we may have a rational dynamical system of units with a minimum of numerical factors. Units arranged according to the first plan are apparently more easily understood, if we may judge by the statements made by elementary students and by some text-books. But in the minds of all who are qualified to judge of these matters, there is no doubt whatever but that the second plan is incomparably superior to the first.

§ 63. **Heaviside's System.**—The dynamical system of electro-magnetic units at present in vogue frequently introduces the remarkable quantity 4π in a way which seems to be regarded by many people as extremely mysterious. We are also informed in many quarters that this 4π is a great stumbling-block in the way of *practical* electricians. Mr. Oliver Heaviside* has shown us where the 4π takes its origin, and has proved that matters could be considerably simplified by defining a unit magnetic pole to be such as acts on an equal pole at 1cm.

* *The Electrician*, October 16, 1891.

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distance with a force 4π dynes, and by making some other changes of a similar nature. The magnetic force inside a solenoid reckoned in this new system would be simply the product of the strength of the current by the number of turns of wire per centimetre length of the coil. If this new system ever comes into use no new determinations of the B.A. Units or other electrical "standards" will be requisite; it will only be necessary to multiply their values by some power of (4π). Whether or not this would be jumping out of the frying-pan into the fire I do not pretend to decide. At any rate, Mr. Heaviside's system merits very careful consideration, in that it gives the very fullest expression to Faraday's grand idea of "lines of force." Dr. H. Hertz,* who has closely followed Mr. Heaviside in his treatment of the equations of the electro-magnetic field, makes use of definitions which, as far as I understand them, appear to be equivalent to those in common use. We shall not, however, pursue this subject any further, but return to the system employed at present.

§ 64. **Electrical "Standards."**—Since we have given up our free choice of units in return for the advantages of a dynamical system, we see that there are, from this point of view, only three things which have any title to be called Standards, viz., the "Mètre des Archives," the "Kilogramme des Archives" and the "Mean Solar Second." (*See* § 2.) The general problem of electrical measurement is the determination in C.-G.-S. measure of some electrical quantity. But even if we have the necessary skill, the great amount of labour involved precludes our making a *direct* determination. We therefore seek for some so-called *standards*, whose values in C.-G.-S. measure can be found with great accuracy by trustworthy experimenters, so that we may be able to base our measurements upon them, and use them as a kind of half-way house. Similar wants make themselves felt even in ordinary mechanics. Thus, when we wish to determine the density, *i.e.*, the mass in grammes of a cubic centimetre of any substance, say copper, we do not make of the copper a cube whose dimensions we can ascertain by comparison with a standard scale, and whose mass we can find by the aid of some standard weights, but we determine the ratio of the density of the copper to the density of water by the aid of the hydrostatic balance. The labours of scientific men have enabled us to find the numerical value of the density of water in tables of physical constants, and thus we are able to calculate the density of the copper. Moreover, a determination of density made in this way by an experimenter of average skill would probably be more accurate than a *direct* determination by the same person, and would certainly be much more expeditious. The really difficult part of the work has been done perhaps years previously by scientific men of the highest attainments, and our belief in their skill and good faith and in the immutability of the properties of water is such that we accept their results and use them in our calculations.

§ 65. **Choice of "Standards."**—The same principles hold good in the case of electrical science, and thus it becomes of importance to decide what electrical quantities shall have their values determined with all possible accuracy in "absolute" measure, so as to be available as "standards" to the electrical world at large. The permanent character and the practical convenience of a properly constructed resistance coil caused the resistance of such a coil to be the first electrical quantity which was determined with any accuracy. The first elaborate "absolute" measurement of resistance in this country was made by the Committee of the British Association in the years 1863, 1864; and as the result of the work of that Committee the British Association Units were issued as "standards."† Later experimenters have shown that the resistances of these coils are not exactly what they were intended to be, and have redetermined their resistances with great accuracy.

Although an accurate knowledge of the resistances of coils is a very great step, and one which enables us to determine in absolute measure the values of several of the electrical quantities, such as, for instance, capacities and coefficients of induction; still there are many measurements which cannot be made by the help of "standards" of resistance alone. It appears, however, that all the electrical quantities can be determined by the aid of *two* "standards." We have chosen the resistance of a certain coil as one of these standards, and now have to decide upon the second "standard." The two quantities from which the choice can be most conveniently made are a current and an E.M.F. Neither of these quantities can, however, be embodied in a material form of the same permanence as a resistance coil, and, in fact, a current cannot be embodied in any material form at all. In the electro-magnetic scheme of units, the unit current is the first *electrical* quantity which is defined; so that it would seem natural to adopt some manifestation of a current as a standard, especially as in any practical method of determining E.M.F. in "absolute" measure, we have to make use of this definition of unit current. But since an electric current is not a thing which can be kept under lock and key, like a resistance coil or a standard voltaic cell, we are obliged to have recourse to some one of the effects of the current. One of these effects, which is most convenient for purposes of measurement, is the electrolytic effect, and this has the additional recommendation that it is proportional to the strength of the current in electro-magnetic measure, as has been shown by Faraday and by Lord Rayleigh. A current is passed through a voltameter charged with silver nitrate or copper sulphate, and, by means of a carefully-constructed electro-magnetic meter or balance, its strength is determined in absolute measure; and in this way a relation is established between the rate of deposition of silver or copper, in grammes per second, and the strength of the current. When once this relation has been accurately established, silver or copper voltameters may be employed in the measurement of currents. It was the object of Lord Rayleigh's work on the "Electro-chemical Equivalent of Silver"* to embody, in a numerical statement, this relation in the case of silver. Strictly, this method is applicable not so much to an electric *current* as to an electric quantity. Lord Rayleigh points out that we might in a more direct way embody our knowledge of unit current in the numerical statement of the rotation of the plane of polarisation of sodium light, which traverses a long column of bisulphide of carbon, encircled by the current a stated number of times.

As regards the choice of *silver*, Lord Rayleigh remarks† that there is not much room for difference of opinion. "The difficulties to be overcome in the case of a water voltameter are much greater. Copper is, indeed, employed in ordinary laboratory practice and for commercial purposes; but it is decidedly inferior to silver both on account of its tendency to oxidise when heated in the air, and also because it changes weight in contact with copper sulphate without the passage of an electric current. Silver, on the other hand, seems to be entirely unaffected by contact with neutral solution of the nitrate." For information as to how far the disadvantages attaching to the use of copper may be overcome, the reader is referred to the work of Mr. Thomas Gray, in connection with the standardising of Sir William Thomson's Electrical Measuring Instruments. (See *Phil. Mag.*, Nov., 1886.)

[The following corrections should be made in the paragraphs appearing on Feb. 5th, 1892:—

On page 347, col. 2, line 7, *for* PQ^2 *read* PR^2.
On page 348, col. 2, line 7, *for* E *read* E(c).
On page 348, line 6 of § 61,
for $\sin\gamma\{2\,F(\sin\gamma)+(1+\sec^2\gamma)\,E(\sin\gamma)\}$
read $\sin\gamma\{2\,F(\sin\gamma)-(1+\sec^2\gamma)\,E(\sin\gamma)\}$]

(To be continued.)

International Electrical Exhibition at Moscow.—An international electrical exhibition, under the auspices of the Imperial Russian Technical Society, is to be held at Moscow from April 14th to October 14th.

* Wiedemann's *Annalen*, Band. XL. 1890; *The Electrician*, August 29, to October 31, 1890.

† Reports of the Committee on Electrical Standards, edited by Fleeming Jenkin. (E. and F. N. Spon.)

* *Phil. Trans.* Roy. Soc., 1884. † *Ibid.*

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JOHNSTONE ELECTRICAL CONDUIT.

Among the various systems of underground conduits for electrical conductors which were described in Mr. J. B. Verity's Paper before the Institution of Electrical Engineers in April, 1889, was that known as the Johnstone conduit, which has been introduced into this country by the International Electric Subway Company, of 39, Victoria-street, Westminster. This conduit was described and illustrated in *The Electrician*, Vol. XXII., page 715; and we give herewith some further details. It is a thoroughly American invention, consisting as it does of very ingeniously designed iron castings of various shapes, which fit together, and enable conduits, manholes, branches, and outlets to be built up and constructed with a very little expenditure of low-class labour. No less than 111 miles of this conduit are at the present time in use in New York, Philadelphia, and other American cities.

The conduit consists essentially of two cast-iron troughs, one forming a cover for the other (Figs. 1 and 2). The

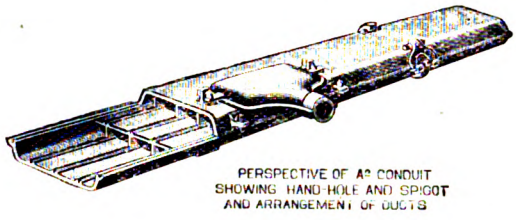

FIG. 1.

dimensions vary considerably, the internal capacity ranging between 233 square inches and 4½ square inches. The larger sizes occupy about the same space as the iron troughs used by the St. James's and Pall Mall Supply Company. The joints are not butt joints, as is usual in most systems, but the upper and lower sections, made in 5ft. lengths, are arranged so as to break joints, and they are clamped together by an ingenious arrangement of keys and wedges. Plumber's putty is relied upon to keep these conduits dry, and this material is laid in all the grooves and abutting ends. We understand that in America this has proved to be sufficient, even in the low-lying parts of New York; but it is well known that in London and elsewhere in this country thoroughly well screwed-up joints, made with red lead, cannot always be relied upon, and the condensation of moisture in the conduit itself is no small difficulty. For the purpose of

FIG. 2.

remedying this, English engineers have had to pay careful attention to drainage; but we understand that no special arrangements are at present provided in the Johnstone system. This conduit is intended for protecting insulated cables, and is not arranged for carrying bare conductors. Shelves are provided, and partitions are arranged on these, in order to keep the conductors in position, but when repairs are necessary the upper section can be removed. As many shelves and partitions as necessary may be slid out, and thus the defective cable may be repaired, without disturbing the others. The upper sections are provided with an attachment for handholes, as shown in fig. 1; this can be placed in front of the house at the time the conduit is laid, or any section may be replaced by one containing a handhole. All castings for branches are arranged with well-rounded corners to prevent chafing of the cables.

Large cast-iron manholes are provided, for the purpose of distributing, and for access to the important parts and branches. It is characteristic of the American practice to construct in cast iron that which is made by most English engineers in brickwork laid in cement. The manhole, of which we give a vertical section (Fig. 3), is built up of a number of plain segments; but any one of these may be replaced by a segment containing an outlet for a conduit, as shown in Fig. 4. One of these manholes has been put together at the offices of the International Electric Subway Company, where we have examined it. There is plenty of room for work inside, but it might often be difficult to find space for it among the pipes under the street.

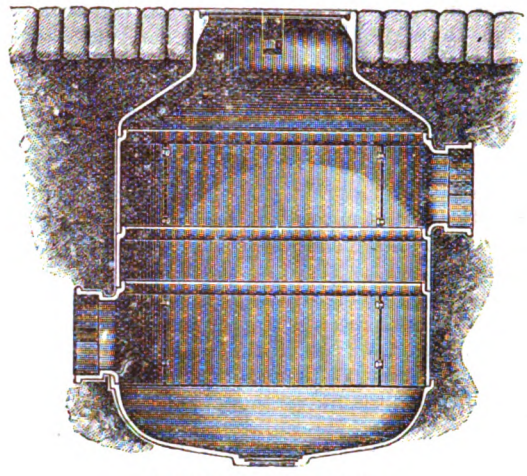

FIG. 3.

The conduit can be laid very rapidly, and the great facilities for interchangeability of all the parts is an important feature. The sections are so arranged that the inside is perfectly smooth, allowing every facility for drawing in the cables. The Subway Company, who appear to be very much averse to the use of lead-covered cables, give an illustration in the pamphlet which they issue of an ingenious method of drawing in. A vertical shaft is fitted, dropping into a step bearing, in the centre of the manhole, and rising three or four feet above the level of the street, and is provided with capstan bars. A barrel is mounted on this spindle at the level of the conduit, and the drawing-in rope is

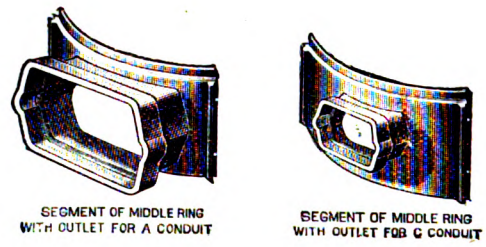

FIG. 4.

wound upon this. As in many other American engineering inventions, this one distinctly aims at being a "system." Whether this will find favour with English electrical engineers cannot be decided by any but those who have to deal practically with the laying and maintenance of conductors below our streets. The samples at the office of the Company are well worth inspection.

Institution of Electrical Engineers.—A students' meeting was held on Friday, the 12th inst., at the Library of the Institution, Mr. James Swinburne presiding. The following students were elected to serve on the Committee for 1892:—Messrs. T. H. Minshall, H. B. Little, C. C. Wharton, R. L. Griffin, A. T. Weightman, S. B. Roth, and H. C. Haycraft, hon. sec. Mr. H. B. Little read a Paper, "Notes on Electroplating." The next meeting will be held on the 26th inst., when Mr. C. Courtenay Wharton will read a Paper on "Some Details of House-wiring."

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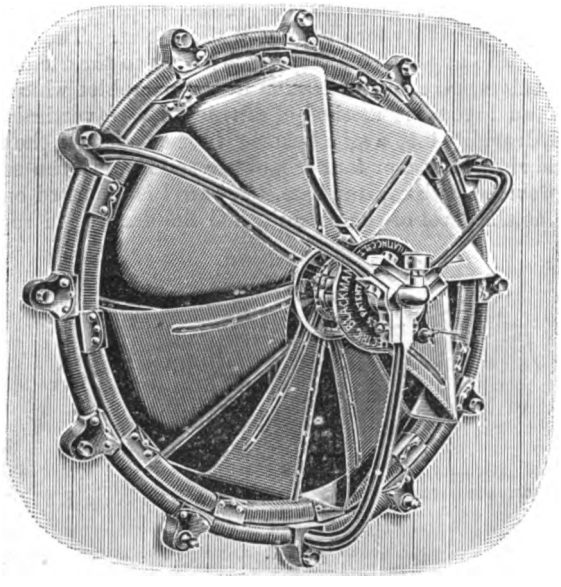
THE ELECTRIC BLACKMAN FAN.

One of the difficulties in the application of electric motors, especially small ones, to mechanical work, is the high speed which it is necessary to employ if reasonable efficiency be desired; and belting or other gearing when applied to half or quarter horse-power motors introduce mechanical losses which may far exceed the electrical waste. Various motors have been tried in connection with the well-known Blackman fan, but the motor has had to be belted down, or run slow, or else the fan has been driven so fast that much of the work has been expended in churning up the air, and has been dissipated in eddies.

There are many obvious advantages in driving a ventilating fan by electricity, as the power required is small, and the fans often have to be distributed in various parts of a building where no mechanical power is being used. In order to drive the fans with economy and at the speed which experience has shown to be the best, a motor has been arranged surrounding the fan itself. The large circumference of the armature enables the speed of rotation to be kept down; and although there appear to be several theoretical objections to the principle, the figures which we have received appear to amply justify the use of this kind of motor. Even if the consumption of electrical energy were the same as in an ordinary small motor, there are several mechanical advantages which are worth mentioning; there is no side pull on the bearings, the wear of the shaft is very largely reduced, and there is little friction other than that due to the end thrust. It is possible by careful arrangement of the parts to reduce even this by the pull of the magnets on the armature. Another advantage is that there is no motor to obstruct the direct flow of the air. The arrangement, which is due to Mr. Watel, of the Blackman Ventilating Company, is clearly shown in the illustration. Both



Electric Blackman Fan.

the armature and the magnet rings are composed of soft iron, well laminated. It is easily fitted up for temporary work, and the smaller size may be connected by an ordinary flexible wire to the nearest lamp socket. As in ordinary multipolar dynamos, the sections of the ring armature are so connected to a commutator that only two brushes are required. This motor, consisting of two large rings, the outer with internal, and the inner with externally projecting poles, closely resembles the motor constructed by Elias of Amsterdam, in 1842. Over 20 of these electric fans were employed at the Frankfort Exhibition, and they are at work at the Crystal Palace. Of the real efficiency of the motor we have at present no information of a scientific character; and when we inform our readers that a two-foot fan, running at 450 revolutions, requires ¼ H.P. to drive it mechanically, but only 100 to 140 watts to drive it electrically, it need not be assumed that the efficiency of the motor is from 133 to 186 per cent. The fact is that electrical energy can be supplied in the most advantageous manner possible, while any mechanical driving must entail some waste, and where belts are used at such a high speed this may be very considerable. These motors have been generally run at about 70 volts; 1½ amperes is sufficient for the 24in. fan, which delivers about 2,700 cubic feet of air per minute, through a duct 2ft. in diameter.

A slow-running motor may some day be a very important desideratum, and we hope that the Blackman Ventilating Company will make a careful test of one of these motors with the blades of the fan removed, since it is impossible to accurately measure the power developed by the fan, unless by a comparison with an independent test of the same fan driven mechanically; and, as we have already pointed out, such mechanical driving must, in most cases, entail serious losses in being transmitted to the shaft of the propeller.

THE RUMOURED AMALGAMATION OF THE EDISON AND THOMSON-HOUSTON COMPANIES.

[COMMUNICATED.]

The rumoured amalgamation of the Edison General Electric and Thomson-Houston Companies in the United States, if true, will be viewed with alarm alike by competitors, local supply companies, and electric railways. To the mind of the general reader such monopolies as the Standard Oil and Western Union Telegraph Company will be at once recalled. Backers of the deal are doubtless past masters in the most approved methods of American "combine." The pooling of interests such as these would be the virtual crowding to the wall of the few independent manufacturers of dynamo-electric machinery; not to speak of the severe blow which would be administered to the Westinghouse Company, and with it indirectly to the extension of alternating-current central stations upon anything but a small scale. The capital of the Edison Company at the present time is about $12,000,000, and of the Thomson-Houston about $10,000,000. So much for the two parent companies proper. The latter also controls or owns the Fort Wayne Electric Company, which manufactures alternating apparatus, and has a capital, the precise figure of which is not known; but is, nevertheless, large; the Brush Electric Company, with an arc, incandescent, and railway system (Short); besides the Excelsior, Schuyler, and a few other small concerns. Local Supply Companies include those which not only supply light and power, but also control the rights of exclusive sale in many cases for the surrounding districts, the parent or manufacturing company in each case owning a preponderating voice in the management in return for the advantages accrued. When it comes to be considered that no cities with any pretensions to size are without a supply company on a large or small scale, a rough estimate may be formed of the vast influence wielded by parent companies, especially when it is stated that outside the Edison and Thomson-Houston no company does a large business except the Westinghouse, and this Company on a much smaller scale than the other two.

Let us take a cursory glance at the status of the local companies in the city of New York. There the sole right to construct and lease subways has been granted to what is known as the Consolidated Telegraph and Electrical Subway Company. This is a pocket interest of the Edison Company. The subways are admitted to be very badly constructed, and difficult to free from illuminating and other gases; but all companies are obliged to lease the ducts at extravagant figures or go out of business. In the meantime the Edison Illuminating Company have constructed from about 58th-street right down to the Battery a network of most excellently-constructed tubes of the regular pattern, the three-wire system of course being used, and so laid down as to allow of all the stations being connected together. This allows of all the stations but one being shut down during the hours of light load. It may not be generally known that all overhead wires are now forbidden, with the

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exception of some of the outlying avenues and districts, where, so far, no subways exist. The local Edison Illuminating Company practically monopolises all the incandescent lighting in the City.

This sample of what is done in Gotham may be fairly construed to represent what takes place in other cities, great and small, in the United States, if not in the Dominion also. Perhaps we may be allowed to digress for one minute to examine into a small "sideplay," which possibly may shed light and explain the means by which the franchise, mentioned above, was obtained. The late Mr. Michael Flynn, of Tammany Hall fame, enriched himself by a commission levied on every length of iron pipe used in the construction of the subways. Doubtless, many another municipal lamb received a *quid pro quo*, which was substantial if not regular.

In the matter of the local railway (tramway) companies the very great majority are owned by either the Edison or Thomson-Houston Companies, or their "sideshows." Such representative roads as the West End of Boston, the Minneapolis and St. Paul, the Cincinnati, Denver, Milwaukee, and other great and small Companies, operate the apparatus of one or other of these two Companies. In fact, fully 80 per cent. of all the electric traction is done by the two above. The isolated lighting business must again amount to a figure, of which people in this country have only a small conception. The value of business done by the Edison Company in the year 1889-1890 was $15,000,000. In 1890-1891 the number of hands in the Schenectady Works of this Company was increased from something like 1,800 to 3,800, so that an estimate may be figured what business was transacted in the latter year. The Thomson-Houston Company have likewise made corresponding increases in their facilities.

We shall now briefly state a few of the patents which would be included in this deal :—Thomson and Brush's patents for arc lighting generators, the Edison glow-lamp patent, Brush's patents (the only valuable ones) on storage batteries, Sprague's railway patents, Van Depoele's ditto, Edison's underground system and three-wire method of distribution, and Slattery's patent for the distribution by transformers in multiple. The above combination will doubtless effect great reductions in the cost of manufacture, but not necessarily in the selling price of apparatus.

These rumours will at once call to mind the pooling, in 1887, of the Westinghouse and Thomson-Houston interests, which deal was proclaimed by loud trumpet blasts. This well-matched team pulled together with as much grace as a thorough-bred mare and a grey mule might be expected to display when hitched up to a band waggon. The result of this partnership was the annulment of the contract in 1888, so that if the latest rumour is true it may be fairly conjectured that something more than a mere combination will be necessary to ensure any permanency.

In conclusion, it may be stated that Mr. W. R. McKee, son-in-law of the President of the United States, is intimately connected with the Thomson-Houston Company, so that the rumour may possibly point to a temporary arrangement for grabbing all the light and power franchises in Chicago during the World's Columbian Exposition.

THE WORK OF JOSEPH HENRY.*

In every well-ordered library stand the volumes of Silliman's *Journal of Science*, the chief repository of the labours of the pioneers, the scientific investigators of our earlier years. If it has been pleasant to dwell in our own words upon Henry's experiment which answered the great question : Can Magnetism produce Electricity? let us now allow him to tell his own story; let us find in the *Journal* the Paper we saw him hurriedly preparing for its pages in those last days of June, after reading the brief notice which told him of Faraday's success. It is dated July, 1832. We give it entire, breaking the thread of the narrative here and there for comment :—

ON THE PRODUCTION OF CURRENTS AND SPARKS OF ELECTRICITY FROM MAGNETISM.*

Although the discoveries of Oersted, Arago, Faraday and others, have placed the intimate connection of electricity and magnetism in a most striking point of view, and although the theory of Ampère has referred all the phenomena of both these departments of science to the same general laws, yet until lately one thing remained to be proved by experiment, in order more fully to establish their identity, namely, the possibility of producing electrical effects from magnetism. It is well known that surprising magnetic results can readily be obtained from electricity, and at first sight it might be supposed that electrical effects could with equal facility be produced from magnetism ; but such has not been found to be the case, for although the experiment has often been attempted, it has nearly as often failed.

It early occurred to me that if galvanic magnets on my plan were substituted for ordinary magnets, in researches of this kind, more success might be expected. Besides their great power, these magnets possess other properties, which render them important instruments in the hands of the experimenter ; their polarity can be instantaneously reversed, and their magnetism suddenly destroyed or called into full action, according as the occasion may require. With this view I commenced last August,† the construction of a much larger galvanic magnet than, to my knowledge, had before been attempted, and also made preparations for a series of experiments with it on a large scale, in reference to the production of electricity from magnetism. *I was, however, at that time accidentally interrupted* in the prosecution of these experiments, *and have not been able since to resume them until within the last few weeks,*‡ and then on a much smaller scale than was at first intended. In the meantime, it has been announced in the 117th number of the *Library of Useful Knowledge*, that the result so much sought after has at length been found by Mr. Faraday, of the Royal Institution. It states that he has established the general fact, that when a piece of metal is moved in any direction, in front of a magnetic pole, electrical currents are developed in the metal, which pass in a direction at right angles to its own motion, and also that the application of this principle affords a complete and satisfactory explanation of the phenomena of magnetic rotation. No detail is given of the experiments, and it is somewhat surprising that results so interesting, and which certainly form a new era in the history of electricity and magnetism, should not have been more fully described before this time in some of the English publications. The only mention I have found of them is the following short account from the *Annals of Philosophy* for April, under the head of "Proceedings of the Royal Institution."

So far, Henry's Paper is introductory. It now gives two series of experiments, *the one made before, the other after* seeing the brief account of Faraday's result. In the first series we find the experiment we have sketched, and if made before April, 1832, the date of the notice, then, before August, 1831, when Henry's experiments stopped.

Before having any knowledge of the method given in the above account, I had succeeded in producing electrical effects in the following manner, which differs from that employed by Mr. Faraday, and which appears to me to develop some new and interesting facts. A piece of copper wire, about 30ft. long and covered with elastic varnish, was closely coiled around the middle of the soft iron armature of the galvanic magnet, described in vol. xix. of the *American Journal of Science*, and which, when excited, will readily sustain between 600 and 700 pounds. The wire was wound upon itself so as to occupy only about one inch of the armature, which is seven inches in all. The armature, thus furnished with the wire, was placed in its proper position across the ends of the galvanic magnet, and there fastened so that no motion could take place. The two projecting ends of the helix were dipped into two cups of mercury, and there connected with a distant galvanometer by means of two copper wires, each about 40ft. long. This arrangement being completed, I stationed myself near the galvanometer and directed an assistant at a given word to immerse suddenly, in a vessel of dilute acid, the galvanic battery attached to the magnet. At the instant of immersion, the north end of the needle was deflected 30deg. to the west, indicating a current of electricity from the helix surrounding the armature. The effect, however, appeared only as a single impulse, for the needle, after a few oscillations, resumed its former undisturbed position in the magnetic meridian, although the galvanic action of the battery, and consequently the magnetic power, was still continued. I was, however, much surprised to see the needle suddenly deflected from a state of rest to about 20deg. to the east, or in a contrary direction, when the battery was withdrawn from the acid, and again deflected to the west when it was re-immersed. This operation was repeated many times in succession, and uniformly with the same result, the armature the whole time remaining immovably attached to the poles of the magnet, no motion being required to produce the effect, as it appeared to take place only in consequence of the instantaneous development of the magnetic action in one, and the sudden cessation of it in the other.

* Abstract of Article III. of a series by Miss Mary A. Henry, appearing in the *Electrical Engineer* of New York. For abstracts of Articles I. and II. see *The Electrician* January 29th and February 5th.

* From Silliman's *American Journal of Science*, July, 1832 ; Vol. XXII. pp. 403—408.

† That is, August, 1831, since the Paper was published July 1, 1832.—M. A. H.

‡ The last two weeks in June (see latter part of the Paper) an interval of ten weeks between the cessation and resumption of the experiment.—M. A. H.

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Notice here Henry's instant recognition of the fundamental conditions of the phenomenon.

This experiment illustrates most strikingly the reciprocal action of the two principles of electricity and magnetism, if indeed it does not establish their absolute identity. In the first place, magnetism is developed in the soft iron of the galvanic magnet by the action of the currents of electricity from the battery, and secondly, the armature, rendered magnetic by contact with the poles of the magnet, induces in its turn currents of electricity in the helix which surrounds it; we have thus as it were electricity converted into magnetism and this magnetism again into electricity.

Another fact was observed which is somewhat interesting inasmuch as it serves in some respects to generalize the phenomena. After the battery had been withdrawn from the acid, and the needle of the galvanometer suffered to come to a state of rest after the resulting deflection, it was again deflected in the same direction by partially detaching the armature from the poles of the magnet to which it continued to adhere from the action of the residual magnetism; and in this way, a series of deflections, all in the same direction, was produced by merely slipping off the armature by degrees until the contact was entirely broken. The following extract from the register of the experiments exhibits the relative deflections observed in one experiment of this kind:

At the instant of immersion of the battery, deflection				40° west.
At the instant of emersion	„	„	„	18° east.
Armature partially detached	„	„	„	7° „
Armature entirely detached	„	„	„	12° „

The effect was reversed in another experiment, in which the needle was turned to the west in a series of deflections by dipping the battery but a small distance into the acid at first, and afterwards immersing it by degrees.

From the foregoing facts, it appears that a current of electricity is produced for an instant, in a helix of copper wire surrounding a piece of soft iron, whenever magnetism is induced in the iron; and a current in the opposite direction when the magnetism ceases; also that an instantaneous current in one or the other direction accompanies every change in the magnetic intensity of the iron.

The Paper now proceeds to give the series of experiments, made in the last weeks of June, 1832, *after* seeing the brief notice of April of Faraday's results.

Since reading the account before given of Mr. Faraday's method of producing electrical currents, I have attempted to combine the effects of motion and induction; for this purpose a rod of soft iron, ten inches long and one inch and a quarter in diameter, was attached to a common turning lathe, and surrounded with four helicos of copper wire in such a manner that it could be suddenly and powerfully magnetised while in rapid motion by transmitting galvanic currents through three of the helices; the fourth, being connected with the distant galvanometer, was intended to transmit the current of induced electricity; all the helices were stationary, while the iron rod revolved on its axis within them. From a number of trials in succession, first with the rod in one direction then in the opposite, and next in a state of rest, it was concluded that no perceptible effect was produced on the intensity of the *magneto-electric* current by a rotary motion of the iron combined with its sudden magnetisation.

The same apparatus, however, furnished the means of measuring separately the relative power of motion and induction in producing electrical currents. The iron rod was first magnetised by currents through the helices attached to the battery, and while in this state one of its ends was quickly introduced into the helix connected with the galvanometer; the deflection of the needle in this case was seven degrees. The end of the rod was next introduced into the same helix while in its natural state, and then suddenly magnetised; the deflection in this instance amounted to 30 degrees, showing a great superiority in the method of induction.

The next attempt was to increase the *magneto-electric* effect while the magnetic power remained the same, and in this I was more successful. Two iron rods, six inches long and one inch in diameter, were each surrounded by two helices, and then placed perpendicularly on the face of the armature, and between it and the poles of the magnet, so that each rod formed, as it were, a prolongation of the poles, and to these the armature adhered when the magnet was excited. With this arrangement a current from one helix produced a deflection of 37 degrees; from two helices, both on the same rod, 52 degrees; and from three, 59 degrees; but when four helices were used, the deflection was only 55 degrees; and when to these were added the helix of smaller wire around the armature, the deflection was no more than 30 degrees. This result may, perhaps, have been somewhat affected by the want of proper insulation in the several spires of the helices; it, however, establishes the fact that an increase in the electric current is produced by using at least two or three helices instead of one. The same principle was applied to another arrangement which seems to afford the maximum of electric development from a given magnetic power; in place of the two pieces of iron and the armature used in the last experiments, the poles of the magnet were connected by a single rod of iron, bent into the form of a horseshoe, and its extremities filed perfectly flat so as to come in perfect contact with the faces of the poles; around the middle of the arch of this horseshoe, two strands of copper wire were tightly coiled one over the other. A current from one of these helices deflected the needle one hundred degrees, and when both were used the needle was deflected with such force as to make a complete circuit.

When two clouds approach each other in the summer sky, the electricity in them is manifested by the lightning which leaps from one to the other. Henry desired a similar manifestation of the electricity he could make his magnets produce, and in the next experiment he obtains this in *the electric spark.*

But the most surprising effect was produced when, instead of passing the currents through the long wires to the galvanometer, the opposite ends of the helices were held nearly in contact with each other, and the magnet suddenly excited; in this case a small but vivid spark was seen to pass between the ends of the wires, and this effect was repeated as often as the state of intensity of the magnet was changed.

The Paper closes with the discovery of the "extra current," which we have shown Henry making in 1829, distinctly inserted here, we ask the reader to notice, as a phenomenon of the same order. Five years later, in 1834, this fact, rediscovered by Faraday, formed another star in his crown.

ELECTRICAL SELF-INDUCTION IN A LONG HELICAL WIRE.

I have made several other experiments in relation to the same subject, but which more important duties will not permit me to verify in time for this Paper. I may, however, mention one fact which I have not seen noticed in any work, and which appears to me to belong to the same class of phenomena as those before described; it is this: When a small battery is moderately excited by diluted acid, and its poles, which should be terminated by cups of mercury, are connected by a copper wire not more than a foot in length, no spark is perceived when the connection is either formed or broken; but if a wire 30 or 40 feet long be used instead of the short wire, though no spark will be perceptible when the connection is made, yet when it is broken by drawing one end of the wire from its cup of mercury, a vivid spark is produced. If the action of the battery be very intense, a spark will be given by the short wire; in this case it is only necessary to wait a few moments until the action partially subsides, and until no more sparks are given from the short wire; if the long wire be now substituted a spark will again be obtained. The effect appears somewhat increased by coiling the wire into a helix; it seems also to depend in some measure on the length and thickness of the wire. I can account for these phenomena only by supposing the long wire to become charged with electricity, which, by its reaction on itself, projects a spark when the connection is broken.

ON THE LAW OF HYSTERESIS.*

BY CHAS. PROTEUS STEINMETZ.

(Continued from page 387.)

III

A third set of determinations of the hysteretic loss of energy is given in the following:—

A magnetic circuit was built up of 17 layers of a soft kind of sheet iron, each layer consisting of two pieces of 20cm. length, 2·54cm. width, and two pieces of 7·6cm. length and 2·54cm. width, of the thickness $\delta = 0686$cm.

Here evident proof of the induction of eddy currents in the iron was found. Especially perceptible was a decrease in the watts consumed by the iron, when a larger M.M.F. of high frequency was left acting upon the iron. This decrease must be attributed to the increase of the electric resistance of the iron, caused by its increasing temperature.

To eliminate this source of error as far as possible, before each set of tests an alternating current of high frequency ($n = 200$), and considerable strength was sent through the magnetising coils, and left on for ten to fifteen minutes, and then first readings with low magnetisation, then with high, and then again with low magnetisation were taken. But, nevertheless, as was to be expected, in these tests the observed values agreed less with each other than in the former readings.

The method of determination, the apparatus, &c., were the same as in the second set of tests, only that ammeter, voltmeter, and wattmeter were used at the same time. In calculating these tests, the law of the 1·6th power was assumed as true, and the loss of energy in the iron expressed by the equation,

$$H = \eta B^{1.6} + \varepsilon n B^2,$$

where

$$H_1 = \eta B^{1.6}$$

is the true hysteretic loss per cycle and cm.^{3}, which is independent of the frequency; and

$$H_2 = \varepsilon n B^2$$

is the loss of energy by eddy current, per cycle, which is proportional to the frequency n.

From this expression,

$$H = H_1 + H_2.$$

* Abstract of a Paper read before the American Institute of Electrical Engineers, New York, January 19, 1892.

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coefficients η and ϵ were calculated, and the agreement or disagreement of these coefficients η and ϵ allow now to check the correctness or incorrectness of the law of the 1·6th power.

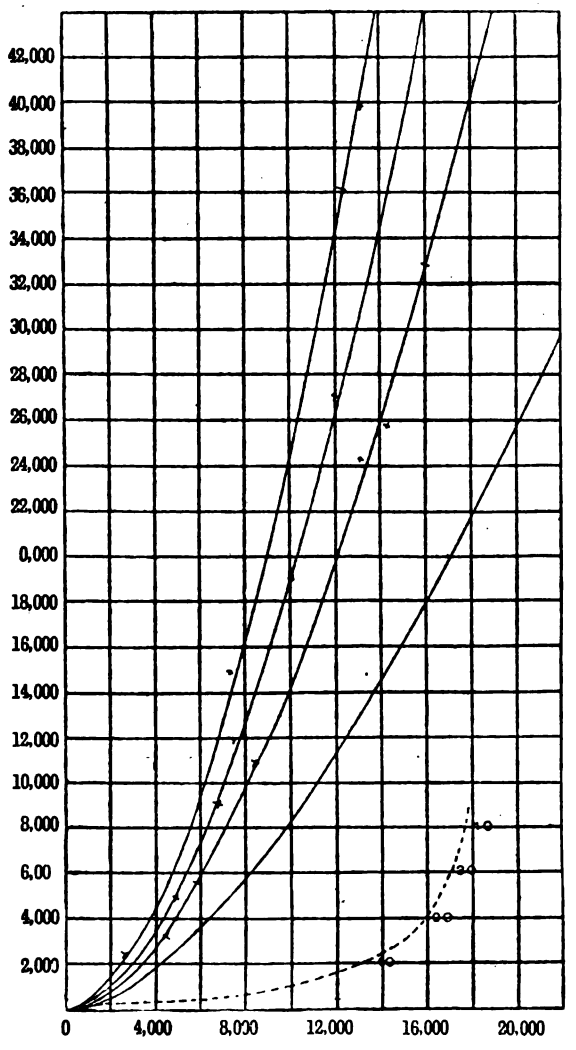

FIG. 4.

These tests gave the following results :—

Magnetic Characteristics.

F = M.M.F. in ampere turns per centimetre length of magnetic circuit.

$\mathfrak{B}$ = magnetisation in lines of magnetic force per square centimetre.

TABLE IV.

F.	$\mathfrak{B}$.	F.	$\mathfrak{B}$.	F.	$\mathfrak{B}$.
1·5	2,700	7	11,700	18	15,450
2	4,350	8	12,200	20	15,800
3	7,100	9	12,700	25	16,400
4	8,850	10	13,100	30	16,800
5	10,000	12	13,900	35	17,200
6	10,800	14	14,500	40	17,500
		16	15,000		

Hysteresis.

$\mathfrak{B}$ = magnetisation in lines of magnetic force per square centimetre.

H = loss of energy by hysteresis, in ergs per cycle per cub.-cm. ($= 10^{-7}$ joules) $= H_1 + H_2$.

$H_1 = \eta \mathfrak{B}^{1·6}$ = loss of energy by hysteresis proper, in ergs per cycle and cm.^{3} ($= 10^{-7}$ joules).

$H_2 = n \epsilon \mathfrak{B}^2$ = loss of energy by eddy-currents, in ergs per cycle and cm.^{3} ($= 10^{-7}$ joules).

Therefrom we get the results :

n = 78, 6 readings,	η = ·00331	$\epsilon = ·751 \times 10^{-6}$	... 1·9 %
140, 6 ,,	·00331	$·730 \times 10^{-6}$	... 2·2 %
207, 5 ,,	·00336	$·757 \times 10^{-6}$	... 1·6 %

The values found for η are so nearly alike that we can consider them as constant, and take their mean value

$$\eta = ·00333$$

as the coefficient of hysteresis.

Even the values found for ϵ are not much different from each other, not more than was to be expected from the unavoidable differences in the temperature of the iron, which, because of the high electric temperature-coefficient of iron, makes ϵ rather variable.

Taking the average of ϵ, we derive

$$\epsilon = ·746 \times 10^{-6}$$

and as formula of iron loss,

$$H = ·00333\, \mathfrak{B}^{1·6} + ·746 \times 10^{-6}\, n\, \mathfrak{B}^2$$

In Fig. 4 are drawn the four curves,

1. True hysteretic loss, $H = ·00333\, \mathfrak{B}^{1·6}$
2. Iron loss for n = 78 $·00334\, \mathfrak{B}^{1·6} + ·00005856\, \mathfrak{B}^2$
3. ,, ,, 140 $·0001022\, \mathfrak{B}^2$
4. ,, ,, 209 $·0001567\, \mathfrak{B}^2$

The observed values are plotted by crosses, +

IV.

Two other sets of determinations of the hysteretic loss of energy, for the frequency 170 complete periods per second, were made on two laminated horse-shoe magnets, with laminated keeper or armature.

The method of observation and of calculation was the same as in III., and the same precautions were taken.

The dimensions of the horse-shoe magnets were :

Mean length of magnetic circuit : 38cm.
,, cross-section : 70cm.^{2}
,, volume of iron : 2,660cm.^{3}
,, distance of keeper from magnet, in the first case : ·15cm.
,, distance of keeper from magnet, in the second case : ·08cm.

each magnet consisting of 300 sheets well-insulated iron, of the thickness ·0405cm.

In the first set of readings, considerable eddy-currents were found ; in the second set, only a small amount of eddies.

The magnetic susceptibility of the iron was not determined, because the reluctance of the magnetic circuit mainly consisted of that of the air gap between magnet and keeper.

The results for the first magnet were

Frequency, $n = 170$.

$$\eta = ·0045 \qquad \epsilon = 1·16 \times 10^{-6}.$$

Therefore we get the formula for the loss in the iron,

$$H = ·0045\, \mathfrak{B}^{1·6} + 1·16\, n \times 10^{-6}\, \mathfrak{B}^2.$$

In Fig. 5 are shown

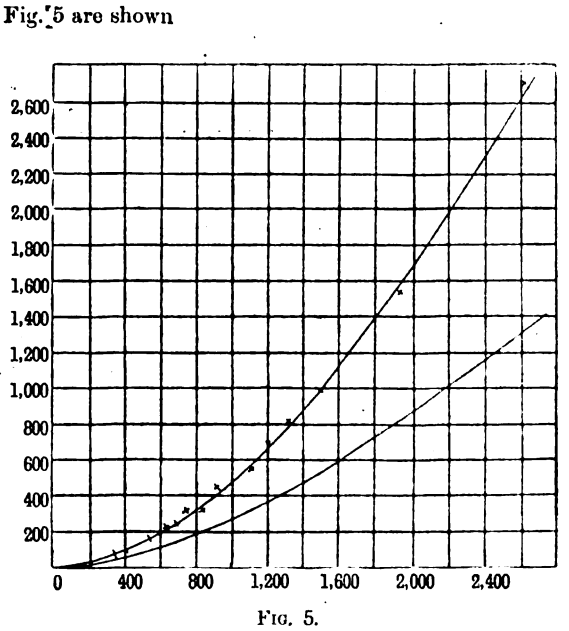

FIG. 5.

1. The curve of true hysteretic loss,

$$H_1 = ·0045\, \mathfrak{B}^{1·6}$$

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2. The curve of the whole loss in the iron,

$$H = H_1 + H_2$$

with the observed values marked by crosses +

For the second magnet the results were

Frequency $n = 170$

$\eta = \cdot00421$ $\epsilon = \cdot2083 \times 10^{-6}$

Therefore we get the formula for the loss in the iron

$$H = \cdot00421\ B^{1\cdot6} + \cdot2083 \times 10^{-6}\ n\ B^2.$$

In Fig. 6 are shown,

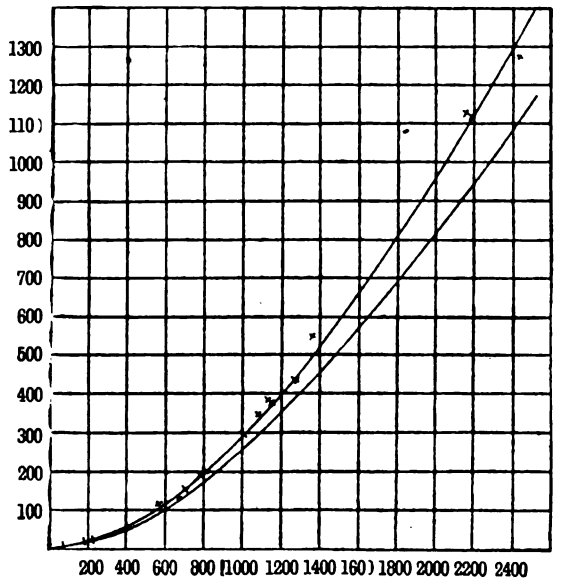

FIG. 6.

1. The curve of true hysteretic loss

$$H_1 = \cdot00421\ B^{1\cdot6}$$

2. The curve of the whole loss in the iron,

$$H = H_1 + H_2$$

with the observed values marked by crosses +

Especially interesting are these two sets of readings in so far as they cover quite a different range of magnetisation as the tests in I. to III.

In I. to III. the tests cover the range from 1,790 to 19,340 lines of magnetic force per cm.^{2}, that is from medium magnetisation up to high saturation, while the tests in IV. cover the range from 85 to 2,600 lines per cm.^{2}, that is, from medium down to very low magnetisation.

The law is found exactly the same,

$$H = \eta\ B^{1\cdot6} + \epsilon\ n\ B^2$$

and herewith proved for the full range from 85 lines per cm.^{2} up to 19,340 lines, a ratio from $1 \div 230$.

This seems not to agree with Ewing's theory of the molecular magnets. According to this theory, for very small magnetisation the hysteresis should be expected to disappear, or almost disappear, and the cycle be reversible. Then for medium magnetisation, where the chains of molecular magnets break up and rearrange, hysteresis should increase very rapidly, and slowly again for saturation. Nothing of this is the case, but hysteresis seems to follow the same law over the whole range of magnetisation, and is certainly not zero for even such a low magnetisation as 85 lines per cm.^{2}

[ERRATA.—The ordinates of Fig. 2 (p. 386) of this article were numbered incorrectly last week, the figures being, by a printer's error, all placed a line too low. The ordinates of Fig. 3 also should read 0, 2000, 4000, &c., and not 0, 4000, 6000, &c.]

(To be continued.)

Armature Resistance.—"Only for the resistance of the armature and field-winding," remarked an engineer, "we could get any amount of current out of a dynamo." This is the truth, but not "the whole truth;" for if the armature and field-winding possessed no resistance, the dynamo would be burned out the very first time it was started up.

DEVELOPMENTS OF ELECTRICAL DISTRIBUTION.*

BY PROF. GEORGE FORBES, F.R.S.

Two distinct problems arose in connection with the electrical utilisation of water-power. It might be used for lighting and other purposes in country houses, &c., or it might be necessary to transmit a large amount of energy to a great distance. It was worth while to introduce a word or two of caution in connection with the use of water-power for house lighting. It was generally a matter of extreme difficulty to find out what was the exact amount of power which could be obtained from a source of supply. In this country there was, as a rule, a superabundant flow of water in winter, and a diminished supply in summer, which was convenient. But it often became extremely doubtful whether the summer supply would be sufficient for the summer demand. It was a most injudicious thing to set up hydraulic plant without taking measurements during the summer. On the other hand, frost in winter often behaved in an unexpected manner, and froze streams which had never been known to freeze before. Even in such cases, however, a saving would be effected if turbines were used in conjunction with a steam plant, owing to the economy of water power. When the source of power was not exactly on the spot another point had to be borne in mind, namely, the proper size of cable to be employed. In many cases with the source of power half a mile away people had acted on the assumption that it would not greatly affect the size of the conductor.

For transmission purposes the alternate-current system was in most cases the best; nevertheless, it was quite easy to imagine circumstances which would make continuous currents suitable. At the present time two types of alternating machines were the best for the transmission of power—the synchronising machine and "rotary phase" machine. It might be worth while to remark that while light alternators would not work well as motors when used with a single pair of conductors, we could use them in the manner described in the previous lecture†, where heavy alternators would be unsuitable.

It was desirable that attention should be drawn to what was being done in Switzerland in connection with the utilisation of water-power. Switzerland was quite in the front rank in this respect. Two large hydraulic systems were in operation at Geneva and Zürich, and being very similar, he would confine his remarks to the former town. At Geneva the Rhone only gave a fall of from 6ft. to 12ft., the higher figure obtaining in the summer when the snows melted. Owing to the small fall, large turbines were requisite. Some twenty were now at work, capable of supplying 6,000 H.P. These large turbines pumped water to a high-level reservoir, whence it was distributed at high pressure to small hydraulic motors all over the town.

The electric lighting of the town was carried on by a separate company. Now the central station was on an island in the Rhone, and close to the turbine station. Nevertheless, the terms upon which hydraulic power was supplied were so reasonable that the company found it more economical to rent what hydraulic power it wanted from the town than to lay down its own hydraulic plant. We therefore had the curious and somewhat anomalous spectacle of a central station, within a hundred yards of the turbine house, driven by water which was first pumped by these turbines to a distant high-level reservoir, and then brought back again.

When we considered the noise, vibration, dirt, and lack of economy of a steam-engine and boiler plant worked under central-station conditions, cases might really arise, even in this country, where saving might be effected by laying down a comparatively small pumping plant, pumping water to a height, and using the water to drive turbo-dynamos. For instance, at Edinburgh it was possible to obtain water and pump it up to the top of Arthur's Seat, 800ft. above the sea level. Loch Dunsappie was already of sufficient cubic capacity to contain a quantity of water capable of supplying 1,000 H.P. for two hours. But a dam could be built across a gully nearer the summit, giving a far greater height. It would cost but little, and in no way mar the beauty of the hill. If we took a station which supplied a maximum of 1,000 H.P.; the average demand would not be more than 150 H.P. A 150 H.P. pumping plant might, therefore, be laid down and worked continuously day and night pumping water to the summit of Arthur's Seat, the head of water so obtained being used to drive turbo-dynamos. Using Loch Dunsappie, and putting the cost of engines and boilers against that of turbines and piping, a great saving in capital outlay would be effected, and a still greater annual saving would be possible. Including losses in pipes a H.P.H. would be available at the turbines for 3lb. of coal, whereas 10lb. to 15lb. was more like the figure reached by central stations. He (Prof. Forbes) had worked this out in the case of Edinburgh for his own satisfaction. The matter had been laid before the authorities, and it was to be

* Abstract of Cantor Lecture II., 4, delivered before the Society of Arts, February 15, 1892.

† *The Electrician*, February 12th. p. 388.

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hoped some such scheme would be adopted. The capital expenditure would be but little more than one-half of that necessary for a steam plant, and the saving in attendance and fuel would also be about 50 per cent.

The increasing use of "destructors" as a means of getting rid of town refuse afforded another source of power. Few engineers had gone into the question of "destructors." His own attention had been called to the matter some years ago, when he was called in to advise Paddington. Since then he had gone into the question carefully, and had inspected a large number of the "destructors" in use. Paddington had a population of 112,000, and 21,000 tons of refuse were annually destroyed in that parish. Assuming this proportion to hold generally and assuming (as was usually done) that each inhabitant required one lamp, then by a wise provision of nature it happened that the average refuse of a town sufficed to generate the average amount of light required by its inhabitants. At Paddington, after deducting all profit, it cost £1,000 per annum to get rid of the refuse. The first "destructors" had not been very great successes, owing to insufficient draught. The type most widely used hitherto was known as Fryer's patent, and was made by Manlove, Alliott and Co. The city which led the way in the scientific use of "destructors" was Leeds, where the destruction of refuse cost 1s. 3d. per ton (interest included).

Prof. Forbes concluded by reiterating his remarks *re* transformer sub-stations and low frequencies.

ART FITTINGS AT THE CRYSTAL PALACE.

We have frequently quoted from the columns of our contemporary, the *Journal of Gas Lighting*, in which very fair comments upon electrical work are often to be found. Mutual admiration is as bad for electrical engineers as for other classes of the community; and a little criticism from their rivals will do them no harm. If the language of the following extract from an article on the Crystal Palace Exhibition is rather strong, we hope to soothe any feelings which may be injured by noticing some really good work on a future occasion.

We all know what the electric arc can do; and the lightness and handiness of the incandescent bulb, with its freedom from flame, would seem to offer a wide range of novel application to the ingenious technician. Our investigation resulted in disappointment. There is a terrible want of originality, and a deplorable absence of taste, observable in most of the exhibits of lighting and lamp-fittings. Electrical science has its Edison, its Swan, and its Brush; but the brilliant stroke of genius that gave the world "French measurement" in electric lighting, exhausted the invention of electricians in this field. The curse of the commonplace lies heavy on the makers of electric light fittings; and it is an object-lesson in the character of the culture of the age to compare the beauty of fitness, as displayed in a modern steam-engine, with the poverty, emptiness, and downright vulgarity of the great bulk of electric light fittings. It is hardly credible, but it is nevertheless too true, that, in the utter debasement of their "art," the fitting makers have taken infinite pains to make imitations of wax-candles-flames and all—out of incandescent lamps! These wretched impositions are to be seen at the Palace by hundreds; and they inspire the thoughtful observer with inexpressible disgust. When the poor ignorant gas-fitters of the early Victorian period put up their glassy imitation candles, surmounted with batswing flames, they knew no better; and the artist in decoration was not then evolved. These fittings would now be regarded as curiosities, wherever found; and we take a little credit to ourselves for having pointed out the absurdity of such imitations many years ago. What might have been pardonable in the uninstructed gas-fitters of the middle of the century, moreover, is abominable in their "advanced" rivals of to-day. These sinners against artistic veracity and consistency are, however, shameless in their turpitude. Take one of the most "bumptious" of them all—the firm of Rashleigh Phipps and Dawson, who have spread themselves very much over the official catalogue. This firm tells purchasers of this publication that their "showcase is after the model of a Mosque at Cairo, and has been specially designed and manufactured by the firm. The lily is introduced in the screen work, after the manner of the Ancient Assyrians, who held it as an object of veneration. The dome is covered in with glass and amber cloth, and is in the form of the breast—a suggestion that Peace nourishes the Arts and Sciences." There is much more of the same style, intended to impress readers with a deep sense of the high-toned work shown in this wonderful stall. Yet here also we find imitation candles "after the manner of the ancient"—gas-fitters! But this firm are not alone. It is the same with Messrs. Benham and Froud, Messrs. Allen and Mannooch, and many others. Sometimes the sham candle-flame is a cylindrical bulb of clear glass with elongated incandescent fibre; sometimes it is in the form of a spiral, frosted or plain, with irregular section, to still more closely copy a flickering candle flame. But, in one or another of these shapes, the scientific decorators of the Palace Exhibition propose this patent lie as the proper thing for their patrons to keep under their eyes daily and nightly! Imagine sitting at a dinner-table so lighted, as may be seen in Messrs. Allen and Mannooch's room in the South Gallery! One would expect to be served with logwood-port, fuchsine-claret, and cider-champagne at such a table; and who could confidently partake of jugged hare, *vol-au-vent*, or other mysterious dish under such a prevaricating light? One firm of exhibitors—Messrs. Frank Giles and Co.—actually go so far as to place imitation wax candles of huge proportions, such as are never seen outside Catholic churches, in one of their specimen rooms, and top these off with ordinary incandescent bulbs. It is difficult to tell the tale patiently. The example just named is perhaps the worst in the list; but an imitation candle, whether large or small, is an outrage hard to be borne. The sight of it is enough to make anybody rush home and light up the real article, with the feeling of relief that here, at least, there is no deception. In order that the subject of these so-called "flame-lamps"—this is, we are informed, their trade name—may be understood, it may be stated that they are a product of the last year or two. They can, of course, be employed quite unobjectionably as "fairy lamps" for decorative purposes. They take 33 volts, and are connected in series of three when the group becomes equivalent to one 100-volt lamp. It requires, however, more taste in lighting than most decorators seem able to command, to employ these or any other description of incandescent lamps in such a manner as to be truly ornamental as well as useful.

THEATRE LIGHTING.—LONDON COUNTY COUNCIL REGULATIONS.

The following Rules and Regulations with regard to the electric light in theatres and other places of entertainment have been adopted by the London County Council:—

Where the electric light is permitted in such premises, it shall be on condition that a competent electrical engineer do certify in writing to the satisfaction of the Council once in six months that the system is in proper working order.

1. All such premises when lighted by electric light shall have at least three separate and distinct circuits (*a*) for the stage, (*b*) and (*c*) for the auditorium, corridors, and exits. The circuits referred to in (*b*) and (*c*) shall be so arranged that half the lights in each division of the auditorium and half those in each corridor and exit shall be on (*b*), and the other half on (*c*) circuit. When the current is supplied by a public lighting company, these circuits shall be taken separately from the street mains.

Under all circumstances complete metallic circuits must be employed. Gas and water pipes shall never form part of any circuit.

The number of lamps shall be so subdivided that no sub-circuit shall carry more than 65 amperes, and each sub-circuit shall start from a distributing board.

2. All conductors used within buildings shall be of copper, having a conductivity equal to not less than 98 per cent. of that of pure copper, and, shall be so proportioned to the work they have to do that, if double the normal current be transmitted, their temperature shall not rise to above 150° Fahr.

The conductors shall be insulated with pure and vulcanised India-rubber. The insulation resistance shall not be less than 300 megohms per statute mile, at 60° Fahr., after one minute's electrification, when tested with at least 400 volts, and after 48 hours immersion in water. The insulated conductors shall be protected on the outside by stout tape or braiding impregnated with preservative compound.

If it is desired to use any other means of insulation than that above specified, special permission shall be obtained from the Council, and no material shall be used which is not waterproof, or which will soften at a temperature below 170° Fahr.

In all cases conductors conveying currents of high E.M.F. inside buildings, shall be specially and exceptionally insulated, and cased in, and the casing made fireproof. The positive and negative terminals connected to such conductors shall not be nearer to each other than 12 inches, and shall be efficiently protected from risk of contact.

Flexible conductors in connection with movable lights shall be insulated with vulcanised India-rubber, and protected on the outside by a stout braiding; should any of these flexible conductors be damaged, it shall be at once replaced. No circuit of this nature shall carry more than 10 amperes, and each circuit shall be protected by a double pole fuse.

3. All conductors shall be efficiently protected from mechanical injury.

When conductors pass through walls, fireproof floors, or ceilings, they shall be protected by iron pipes or by glazed stoneware or porcelain tubes, and precautions shall be taken to prevent the possibility of fire or water passing along the course of the conductors.

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In special cases, or where necessary for protection from the depredations of rats, mice, or other vermin, armoured cables may be used. These need receive no further mechanical protection.

Lead-covered cables shall not be used unless protected by external armour of iron or steel.

Metal fastenings for fixing conductors shall be avoided; but when unavoidable some additional covering shall be used to protect the conductor, unless armoured, from mechanical injury at the points of support.

If casing be used it shall be of hard wood, and each conductor shall be laid in a separate groove; the cover shall be secured with screws. Casings shall, as far as possible, be placed in sight, and the conductors shall always be accessible.

Joints in conductors shall be avoided, but when unavoidable, they shall be electrically and mechanically perfect. Soldering fluids shall not be used in making such joints.

4. All external conductors shall be specially insulated and laid in iron pipes properly jointed, and of ample size. Such iron pipes shall be protected where necessary, and securely fixed and supported when not underground.

5. All exposed metal work, such as fittings, switch and fuse covers, &c., shall be efficiently insulated from the circuits.

All switches, cut-outs, ceiling roses, wall and floor sockets, and lamp-holders shall have uninflammable bases. All switches shall be of ample size to carry the currents for which they are intended without heating, and shall be so constructed that it will be impossible for them to remain in any position intermediate between the "on" and the "off" positions, or to permit of a permanent arc. All circuits shall be efficiently protected by cut-outs, placed in positions easily accessible to the staff, but inaccessible to the public. The main cut-outs shall be of such pattern and be fixed in such a position as to admit of quick replacement. All circuits carrying a current of 20 amperes or more shall be provided with a cut out on each conductor, and the two cut-outs shall not come in the same compartment. All cut-outs shall be so constructed that fused metal in falling cannot cause a short circuit or an ignition. All cut-outs shall be so marked as to show what circuit or lamps they control. All wall or floor sockets shall be provided with fuses in their fixed portions. The sockets for the stage shall be of hard wood with metal guards, care being taken to avoid risk of ignition, and they shall be of specially substantial construction.

6. Resistances, for regulating the power of the lights, shall be mounted on incombustible bases, and shall be so protected, and placed at such a distance from any combustible material, that no part of the resistance, if broken, can fall on such material.

Principal resistances sha'l be placed in a fire-proof room reserved for the purpose.

7. Arc lamps shall not be used inside buildings without special permission from the Council.

When they are used, special precautions shall be taken to guard against danger from falling glass or incandescent particles of carbon. All parts of the lamps, lanterns, and fittings which are liable to be handled (except by the persons employed to trim them) shall be insulated.

8. Where there is a stage, special care shall be taken that all works in connection with the lighting of the stage are carried out in as substantial a manner as possible.

No metal work in connection with the circuits shall be exposed, or so fixed or constructed as to be liable to cause a short circuit.

Lamps on battens, footlights, &c., shall be protected by stiff wire guards, so arranged that no scenery or other inflammable material can come in contact with the lamps.

No readily combustible material shall be used in connection with any lamps on the stage in such a manner that it might come in contact with the lamps.

No soft or readily inflammable wood shall be used in connection with the lamps on the stage, and all wood shall be protected by uninflammable material from the possibility of ignition by an arc between any two parts of the two conductors, or by heated particles from any conductor or part of a conductor which may connect together the two main conductors.

Where a number of lights, as in the footlights, battens, &c., are supplied under control of one switch, and protected by one single or double pole cut-out, as the case may be, the conductors shall be maintained throughout of such a section that they will be effectually protected by the cut-outs against heating.

The leads to the battens shall be specially guarded, particularly at the points where they join on to the battens, and a sufficient length shall be allowed to prevent the leads receiving any injury through any movement of the battens.

The battens shall be suspended by at least three wire ropes attached to insulators on the battens.

On no account shall the same battens be adapted for both gas and electric light.

9. A switchboard, containing all the necessary switches, cut-outs, and other fittings for the control and regulation of the stage lighting, shall be fixed in some convenient position overlooking the stage. This board shall be inaccessible to all but the persons employed at such premises to work it.

10. Boilers, steam engines, gas engines, and dynamos, when used for the supply of electricity to such premises, shall be placed in such positions as shall be sanctioned by the Council.

Gas engines shall be placed in rooms so adequately and continuously ventilated that no explosive mixture of gas can accumulate by any leakage through the engine in the event of any of the gas cocks being left turned on. A hood, connected with a pipe carried into the external air, shall be fixed over the ignition tube when this is used.

11. Primary or secondary batteries shall be placed in rooms so adequately ventilated that no fan shall be necessary. The batteries shall be well insulated.

12. Transformers used to transform either direct or alternating currents, together with the switches and cut-outs connected therewith, shall be placed in a fire and moisture proof structure. Where the primary current is of high potential, such structure should be preferably outside the building. No part of such apparatus shall be accessible except to the person in charge of its maintenance.

No transformer which, under normal conditions of load, heats above 130° Fahr. shall be used.

Transformer circuits shall be so arranged that under no circumstances shall a contact between the primary and the secondary coils lead an E.M.F. of high pressure into the building. The term high pressure means in all cases pressure above 200 volts.

13. The insulation resistance of a system of distribution shall be such that the greatest leakage from any conductor to earth, when all branches are switched on, the lamps and motors being removed, shall not exceed one fifteen-thousandth part of the total current intended for the supply of the said lamps and motors, the test being made at the usual working electromotive force. Provided that this rule shall not be held to justify a lower insulation resistance than 5,000 ohms, nor to require one higher than 5 megohms.

14. The generating plant and switching gear shall be in the hands of thoroughly competent manipulators, and the engine-room (if any) shall be inaccessible to the general public, and shall, where possible, have an independent entrance.

15. A plan of the wiring shall be always kept in a prominent position n the office of the manager of such premises.

ELECTRIC PERCUSSION DRILLS.

Several installations of electric percussion drills, says the *Engineering and Mining Journal* of New York, have been made in mines in various parts of the country during the past year; and it must be confessed that the results obtained from these machines in practice have not borne out the expectations that were based upon the experiments made in the manufacturers' workshops. It has been demonstrated by actual work in the mines that the electric drills are of faulty construction; and although this defect can doubtless be easily corrected, it would appear to be a more serious matter to overcome the chief trouble, viz., the heating of the solenoids and piston. All of the electrical percussion drills which have been invented so far are based upon the same principle, consisting of two or three solenoids, within which works an iron core or piston (*The Electrician*, November 6, 1891, p. 9). The reciprocating motion of the latter is attained by sending an electric current first through one solenoid and then through the other, the iron core being alternately attracted, first in one direction and then the other. The other parts of the drill, the piston-rod, the rifle-bar, the feed-screws, the tripod, &c., are in general form similar to those used in the ordinary types of steam and air drills. There is an essential difference, however, in the fact that the piston-rod and rifle-bar have to be constructed of non-magnetic material in order not to interfere with the balance of the piston within the solenoids. The heating of the solenoids seems to be due to the rapid reversing of the electric current through their coils. This not only means such loss of power as to make the drills uneconomical, electrical energy being converted into heat which should be converted into mechanical work, but the heating is often so intense as to make the drill objectionable in a small mine heading. Several months ago an important installation of these drills was made in the Ute and Ulay Mines at Lake City, Colo., from which much was expected. The plant was completed and ready to run about September 10th, and the experiments continued through September and October. Many mechanical difficulties were encountered, some of which were overcome, but the great trouble was the heating of the machine. After much work upon this problem, the electricians decided to give it up for the present. A like experience was had at the Last Chance Mine, at Wardner, Idaho. Although the electric percussion drills have not realised expectations, it is not to be inferred that they will not eventually become successful. Indeed, the haste of the manufacturers in putting them in the mines before they were fully tested, is probably accountable for this temporary set-back. The inventors are now endeavouring to overcome the defects that have been shown, and such bright minds as Edison, Thomson, and Van Depoele cannot long be denied.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February* 5, 1892.

Rumoured Amalgamation of the Thomson-Houston and Edison Companies.—The principal rumour of interest in electrical circles just now is the alleged formation of a combination between the Thomson-Houston and Edison Companies. This has been reported at various times in the past, but never with so much substantial foundation as now. It is known that consultations between the officials of these companies have been several times held recently, and to-day the understanding is that a definite result has been reached. The details, of course, are totally unknown, but it is altogether probable that the Thomson-Houston Company has the butt of the whip. One of the rumours which seems to be generally believed is that a gigantic corporation will be formed, in which both companies will be merged, perhaps without entirely giving up their individual organisation. Mr. C. A. Coffin, president of the Thomson-Houston Company, is supposed to be at the head of the combination. It is suggested further that the incandescent lighting business for both isolated plants and central stations, the manufacture of lamps, fittings, cables, and the like, together with the exclusive manufacture of generators, will be given to the Edison organisation, the Thomson-Houston running the transmission of power, railway, and mining business. This, of course, is pure hypothesis. There is some foundation for the rumours, although nothing can be definitely confirmed until after the Edison Company's next meeting, and possibly not until the Thomson-Houston meeting in March. The stock of both companies has risen very rapidly, Thomson-Houston, par value of 25, being quoted last night at 59, and Edison, par value 100, at 103. That Mr. Henry Villard will go is generally admitted, and it is understood that Drexel, Morgan & Co. now have the control of the Edison organization. The result of such a combination of the two organizations would be a tremendously powerful corporation that would acquire and retain a very large proportion of the electrical work of the country. It would also prevent the ruinous cutting of prices that has been indulged in during the last year. There is a strong feeling, too, in the trade that the supply business is likely to be taken up by the large companies, making it hard for the small dealers to live. Meanwhile, with all this, there is a promise of a very large amount of construction work the coming season, enough to keep all the companies busy.

A Novel High-Speed Electric Railway.—A Company has recently been organised for the purpose of running a high-speed electric railway between Chicago and St. Louis, a distance of 250 miles. Their plans look formidable on paper, but there does not appear to be any general confidence that anything serious will result. The proposition to operate a 250-mile road from one station is enough to cast considerable doubt on the genuineness of the scheme even if nothing more were said, and the plan of buying up the land along the track and building a grand residence boulevard between the cities, seems almost equally absurd. We are doubtless to have high-speed electric roads in the near future, but hardly of the character suggested.

The Proposed Adoption of Electricity on the Illinois Central Railway.—The Illinois Central, which has proposed the extensive use of electricity in its suburban traffic, appears now to have decided to do nothing until after the World's Fair, feeling that the time is not quite ripe for such a change, especially on the eve of an unprecedented heavy traffic. The Illinois Central is said to have the largest suburban traffic of any single road in the world, and is therefore cautious about inaugurating a change.

BOOKS, &c., RECEIVED.

"On the Telephoning of Great Cities, and an Electrical Parcel Exchange System." By A. R. Bennett, M.I.E.E. (London: Whittaker and Co.)

"The Year's Naval Progress." (Washington Government Printing Office.)

CORRESPONDENCE.

THE EXCITATION OF VACUUM TUBES WITHOUT ELECTRODES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think that a reprint of the following letter may, even now, be not without interest to some of your readers. It explains the electrostatic excitation of vacuum tubes without electrodes. The letter was originally printed in *Nature*, Jan. 6, 1881:

TO THE EDITOR OF NATURE.

SIR: At a meeting of the Philosophical Society of Glasgow, on December 22, I gave a very brief preliminary account of some experiments that I have been making, along with Sir William Thomson, with vacuum tubes. We have sealed up English and German glass tubes with very high vacuums, but without any electrodes; and have obtained very remarkable luminous effects both with the Ruhmkorf coil, and also working by means of electrostatic induction. Using an ordinary frictional electric machine, and applying one end of a long vacuum tube to the prime conductor, while the other end of the tube is held in the hand, the tube becomes charged as a double Leyden jar in the following way:—One end of the tube next to the prime conductor—outside positive, inside negative; the other end—inside positive, outside negative. This can be shown by the gold-leaf electroscope. The charges seem to be very high and the glass is very frequently perforated. Indeed, it is difficult to work with the electric machine in tolerably good order without perforating the glass. While this double Leyden jar is slowly discharged by removing, part by part the charges from the outside of the tube, beautiful luminous effects were observed, very different from those seen in the ordinary vacuum tubes. We have also obtained curious effects by heating the middle region of the tube so highly that it becomes a semi-conductor. J. T. BOTTOMLEY.

Physical Laboratory, University, Glasgow, Dec. 29, 1880.

The electrostatic mode of excitation ought, obviously, to be clearly distinguished from the method used by Prof. J. J. Thomson, in the experiments which he showed so beautifully to the Physical Society at Cambridge last June. The illumination of the tubes when the Ruhmkorf coil was employed was, probably, not wholly electrostatic. The tube was simply held in the hand above the line where the sparks from the coil were passing, and in these circumstances became illuminated.—Yours, &c., J. T. BOTTOMLEY.

Feb. 13, 1892.

THE SPECIFIC RESISTANCE OF COPPER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have lately had to deal with two samples of copper strip obtained from the same firm, and have found that the specific resistance of one specimen is 2·9 times as great as that of the other. I should be glad to know whether there is often so great a difference among samples of commercial copper. The copper was obtained from a firm of the very highest standing.—Yours, &c., G. F. C. SEARLE.

Cavendish Laboratory, Cambridge, Feb. 15, 1892.

TESLA'S EXPERIMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: While impressions of Mr. Tesla's experiments are still fresh in the minds of those present at the Royal Institution, I ask permission to call attention to one or two points that may refer to the nature of electricity and magnetism.

An insulated conductor was suspended from above the head of the lecturer to the front of the gallery and back again, in two lines slightly converging towards the gallery. When this conductor was placed in the electric circuit and the room darkened, its whole length glowed with a beautiful violet haze, appearing equally vivid at all parts of the conductor. The haze surrounding the conductor in that space we find imbued with magnetism, when current is passing. Mr. Tesla also connected up two bare wires of circular form, and different diameters, placed concentrically and in the same plane. These, likewise, showed the same violet haze, but directed (like streamers of the aurora borealis) towards each other. In this last experiment the haze seemed less vivid than in the former one, and I should like to know if this is the opinion of others who were present. Of course, the frequency or potential may have been changed, or the relative position of the conductors may affect the haze; but, as we found that a di-electric placed between two sparking terminals facilitated the discharge, it may be that the haze was increased by the use of insulation. If this be so, it is important to know under what change of conditions insulation would cease to facilitate

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discharge or vary the magnetic haze, as it might then be used as a test of the quality of insulating material.

My next point is that the violet or magnetic haze would imprint an image on a sensitised photographic plate probably without the aid of a lens or other light than its own. We know how sensitive such plates are to blue and violet rays of the spectrum; and we know that stars, never seen by man, appear on plates after a lengthened exposure. By calling in, therefore, the aid of another branch of science, we may yet be able to see the exact image of varying electrical or magnetic conditions permanently recorded and comparable at sight; and we may also hope to acquire further knowledge of these subtle forms of energy.—Yours, &c.,

London, W.C., Feb. 15, 1892. J. SINCLAIR FAIRFAX.

LEGAL INTELLIGENCE.

Crompton and Co. v. Lane-Fox.

In the Queen's Bench Division of the High Court of Justice, on Monday, the case of Crompton and Co. *v.* Lane-Fox came before Mr. Justice Day, sitting without a jury. This was an action brought by the plaintiffs, electrical engineers, carrying on business at Chelmsford and London, against Mr. Lane-Fox, also an electrical engineer, to recover £150 alleged to be due under a contract. The defendant denied liability.

Mr. Bankes appeared for the plaintiffs, while Mr. Forbes Lankester represented the defendant.

Mr. BANKES, in opening the case for the plaintiffs, said his clients were well-known electrical engineers; and Mr. R. E. Crompton, the head of the firm, was a friend of the defendant, who was also engaged in electrical engineering. The plaintiffs were in the habit of taking pupils, and their premium was £300 for three years' tuition, £150 being paid down when the pupil commenced his articles, and the balance at the expiration of a certain period. These terms were well known to the defendant. About April, 1886, the defendant had a brother who was about leaving college, and he was anxious that his brother should become a pupil of the plaintiffs. On April 4th the defendant wrote to the plaintiffs, asking them if they could take any more pupils, as his youngest brother, who was just leaving Cambridge, wished to become an electrical engineer. Subsequently the defendant and his brother went down to Chelmsford, and saw Mr. R. E. Crompton, and it was arranged that the brother should come for a month on probation. At the end of the month the plaintiffs felt that the brother was not likely to prove a success, and they communicated their opinion to the defendant Another interview took place, with the result that the young man was taken on for a second month's probation. At the end of the second month the plaintiffs felt that the brother had improved, and they arranged to accept him as a pupil on the usual terms. Mr. Crompton was told by the defendant that his father, General Pitt Rivers, was abroad, and that the premium could not be paid until the father returned. Some time after General Pitt Rivers returned to this country, and the plaintiffs, at the suggestion of the defendant, wrote to the father asking for the payment of the premium. The father replied that he had given no authority for the lad to be placed with the plaintiffs, and that he refused to have anything to do with the arrangement. On being informed of his father's reply the defendant agreed to pay the half premium, £150, in about three weeks. The brother remained with the plaintiffs until the following June, when he left.

Mr. R. E. Crompton, of the firm of Messrs. Crompton & Co., stated that it had been the practice of his firm to take pupils on terms which were known to the defendant. On 4th of April, 1886, he received a letter from the defendant asking him if he could take his brother as a pupil. Subsequently the defendant and his brother came down to Chelmsford, and it was then arranged that the brother should come on a month's probation. At the end of the month he wrote to the defendant, telling him that his brother was not getting on well, and that he did not think he would ever make an engineer. The defendant asked him to try his brother a little longer, and he (witness) agreed that he should remain another month on probation. By the end of the second month defendant's brother had made considerable progress; and witness had a conversation with the defendant, with the result that it was agreed the brother should become a pupil for three years. The defendant said his father, General Pitt Rivers, was abroad, and that the premium, &c., would be arranged as soon as he returned. After waiting some time, witness asked the brother why he had not heard about the premium; and the brother recommended him to write to his father. Witness after having communicated with the defendant, wrote to the father, who replied that it was the first time he had ever heard of the matter. He (witness) thereupon saw the defendant and told him the purport of his father's reply. The defendant said he would have to make some arrangement himself. Subsequently, on the 19th of January, he received a letter from the defendant promising to pay half of the premium. The brother remained with the firm until the following June, when he left of his own accord. He should not have allowed the brother to remain at the works if the defendant had not written the letter of the 19th of January.

The further hearing of the case was adjourned.

On Tuesday morning when the plaintiff was about to be further cross-examined, a consultation took place between the learned counsel and their respective clients, with the result that Mr. Bankes said it had been arranged that there should be judgment for the plaintiffs for £150 with costs. Judgment in accordance with the terms arranged.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.

The tenth annual edition of the above well-known annual is now ready, price 7s. 6d.; post free, in the United Kingdom, 8s. 3d.; abroad (with the exception of a few countries), post free, 8s. 10d.

The edition consists of between 900 and 1,000 pages, and special care has been taken to make the Directorial division of the book, which has been considerably extended, thoroughly accurate and reliable.

To the Handbook division has been added several features which will be found of service to the Electrical and Allied Trades. The Digest of the Law of Electric Lighting has been thoroughly revised and brought up to date, and the most recent Board of Trade Regulations are also included. The various tables and tabulated statements relating to Central Stations, Electric Railways and Tramways, &c., have been made complete; the tables giving useful data relating to dynamos, alternators, motors, transformers, batteries, &c., have been remodelled and amplified; and a new feature is the tabulation of valuable information respecting Electrical Limited Liability Concerns.

An important feature is the space devoted to the officials of Foreign and Colonial Governments who have the superintendence of contracts and the giving of orders for electrical plant and apparatus; and as this has been kindly supplied by the various Government departments, it can be relied upon, as can also the particulars given respecting the Home Government departments.

The profession will find "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK a trustworthy work of reference, and purchasers of plant and apparatus may confidently turn to its pages for the names of all the principal firms supplying their requirements. Nearly every firm of any standing in the Electrical and Allied Trades is represented in its advertisement pages.

A digest of the contents of the book will be sent on application.

TENDERS INVITED.—The Secretary of the Earl's Court Exhibition Syndicate (Limited), West Brompton, invites tenders for lighting the Exhibition buildings and grounds at Earl's Court during the coming season, from the beginning of May to October, 1892. Particulars can be obtained by writing to the Secretary, at West Brompton, London, W.

——— We are asked to state that Mr. W. B. Hutchinson has now finished the specification for the electric lighting of Heckmondwike, Yorkshire, and that tenders are invited. Plans may be seen at the Surveyor's office.

——— The Spanish Department of Posts and Telegraphs invites tenders for the supply of 25,000 telegraph insulators, 3,000 telephone insulators, and 60 tons of 4mm. iron wire. Tenders are to reach the offices of the Department, Calle de Carretas 10, Madrid, by 2 p.m. on March 10th.

TENDERS ACCEPTED.—Galloways (Limited), Manchester, have received the order for the six boilers and four large engines for the Manchester Corporation electric light installation. The boilers will be 30ft. long by 8ft. diameter, of ⅝in. steel plates for 125lb. pressure, and will be fitted with mechanical stokers as well as double sets of steam and feed arrangements. The engines will be vertical, 17in. and 34in. cylinders, 3ft. stroke, each to give off 360 brake H.P. (or 1,440 in the aggregate), with a piston-speed of 500ft. per minute, and will be provided with special arrangement of condenser. All have to be at work by the end of July. Dr. J. Hopkinson, of Victoria-street, Westminster, is the engineer.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—This Company has recently issued its general conditions for wiring houses for the electric light, for use by the Company's customers. The first clause sets out that the work of wiring is generally to be carried out in accordance with the rules of the Institution of Electrical Engineers and of the Company in whose office the building is insured. No conductor of a less total area than No. 18 S.W.G. is to be used, except in the case of flexible cords, which may be equal in section to No. 20 S.W.G.; all copper to be tinned if the insulation is vulcanised. The house mains from the consumers' terminals will be taken (with the meter placed in one or two of the leads) by means of two or three conductors to distribution boards, and will thence be divided into such circuits that the current in any one will not exceed 12 amperes at times of full load. Throughout the system, one main or wire will be coloured red and the other black; all single-pole cut-outs and switches will be placed in the conductor coloured black. Installations, when tested by the Company at the full working pressure, will not have a lower insulation resistance than at the rate of 75 megohms per lamp, with all fittings and apparatus connected; and any installation failing to comply with this rule will not be supplied with current by the Company. With

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the above exceptions, the rules agree generally with those of the other Metropolitan Supply Companies, full details of which will be found in the new issue of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, pp. 133-138.

CLECKHEATON.—The new Town Hall at Cleckheaton, which was opened last week, is lighted throughout by electricity. A 14 H.P. Otto gas engine drives a compound-wound Castle dynamo, manufactured by Messrs. J. H. Holmes and Co., of Newcastle-on-Tyne. In the large hall there are 10 "Sunbeam" lamps of 200 c.p., each suspended from the ceiling, which can be lowered at will for cleaning or renewals, whilst under the gallery are 12 glow lamps of 16 c.p. The platform is lighted by eight glow lamps, fixed to the walls on handsome brackets, and also by 12 footlights of the same capacity, arranged on a fitting specially designed for the installation. A lamp of 50 c.p. is fixed in the porch, and four similar lights are placed in the crush rooms. The offices, workshops, stores, &c, are efficiently lighted, the number of lamps being 10 of 200 c.p., 135 of 16 c.p., and half-a-dozen of 50 c.p.

LAMBTON CASTLE.—A new electric lighting plant has recently been completed for the Earl of Durham, at Lambton Castle. The two engines are the latest type of Parsons' steam turbine, running at 4,000 to 5,000 revolutions, direct coupled to the dynamos, which are shunt-wound. Each set of engine and dynamo gives 32,000 watts, at a pressure of from 115 to 150 volts. Two Cornish boilers, 24ft. 0in. long by 5ft. 6in. diameter, work at a pressure of 100lb. per square inch. In addition to the plant illustrated, a battery of accumulators has been provided, capable of maintaining 220 60-watt lamps for nine hours, or up to 400 such lamps for a shorter period. The reconstruction of the wiring, as well as the new plant, has been arranged throughout by Mr. A. A. Campbell Swinton.

BRITISH INSULATED WIRE COMPANY (LIMITED).—We understand that this Company (the first annual meeting of which is reported in another column) intend to go in for electric light contracts, and that they have already made arrangements with the Earl of Derby to light Knowsley Hall by electricity, and that other large contracts are being negotiated. The Company in August last purchased the Ferranti mains patents for a considerable sum, and Mr. Ferranti has joined the Board of Directors, which includes many gentlemen of note in the commercial world.

FIRE.—The premises of Messrs. Hodges and Todd, electrical engineers, Verulam-street, Gray's Inn-road, were destroyed by fire yesterday morning. Business will be carried on as usual in temporary premises.

PULSOMETER ENGINEERING COMPANY.—We have received from this Company a very attractively printed pamphlet, "A Chat about a Successful Invention," which contains a quantity of information regarding the well-known Pulsometer pumps and valves, and shows the Pulsometer in use in a variety of positions and under many conditions where no other pump could be conveniently used.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

February 8, 1892.

2,365. A. F. MABON. Glasgow. Improvements in electrical communicating apparatus for mining and other works.

2,393. W. GRIGG. London. Improved method of and appliances for using electricity as a medicinal agent.

2,397. E. D. WISE. London. Electric fire-alarm.

2,401. P. GRANT. London. Improvements in incandescent lamps.

2,417. R. J. CROWLEY. Queenstown. Apparatus to gather and store electricity or energy from water, the earth, or from the atmosphere.

February 9, 1892.

2,438. G. SACCO. London. Improvements in relays for submarine telegraphy.

2,448. W. F. WENTZ. Manchester. Improvements in and connected with the arrangement and operation of relays in telegraphic systems.

2,458. J. G. POOL, N. W. and J. E. HUBINGER. London. Improvements in ring armatures.

2,486. P. H. HOLMES. London. Improved composition of matter suitable for use in the manufacture of journal bearings, packings, projectile rings, commutator brushes, and various other articles where surfaces come into frictional contact, and for conductors of electricity.

2,488. S. L. TRIPPE. London. Electric lighting system.

2,497. J. HUNT. London. Improvements in magneto-electric machines.

2,540. J. E. WALLER. London. Improvements in the arrangements of conductors for electric traction.

2,541. B. H. C. BOGLER. London. Apparatus for and method of recording the time during which telephones, phonographs, and other instruments or machines are in use or at work. (K. Strecker, Germany.)

2,544. A. J. BOULT. London. Improvements in electrical motors. (W. J. Still.)

February 10, 1892.

2,588. E. F. FURTADO and C. B. OAKLEY. London. Improvements in telephonic switching apparatus.

2,606. R. G. GOATCHER. London. Improvements in the electro-pneumatic action of organs.

2,618. P. BARY. London. Improvements in electro-motors.

2,619. A. LE COCQ DE LAUTREPPE. London. An improvement in the electro-plating of organic substances. (H. Pottier, France.)

2,621. Sir C. S. FORBES, Bart. London. An improved telephone combination.

SPECIFICATIONS PUBLISHED.

1890.

20,651. MANCE. Electrical transformers. (Price 6d.)

1891.

1,049. DE FERRANTI. Dynamo electric machines. (Price 8d.)

1,051. DE FERRANTI. Electrical transformers. (Price 11d.)

1,051A. DE FERRANTI. Testing electrical transformers, &c. (Price 8d.)

4,689. CHALIS. Electric switches. (Price 8d.)

4,988. THOMPSON. Type-printing telegraphic instrument. (Price 8d.)

5,131. LAWRENCE. Applying electricity for therapeutic, &c., purposes. (Price 8d.)

5,341. POLESCHKO. Electrical transformers. (Price 8d.)

5,406. JOBSON. Telegraph pole attachments. (Price 8d.)

5,485. MASSIN. Telephonic communication. (Price 8d.)

6,232. GWOSDEFF and BUNGÉ. Microphones for telephonic circuits. (Price 8d.)

12,824. ZANNI. Electric lighting. (Price 6d.)

13,705. SHIELS. Coupling electric wires. (Price 6d.)

20,367. SHIELS. Electric wire couplings. (Price 8d.)

20,933. DEWEY. Electrically propelled hose carts. (Price 8d.)

21,476. WATERHOUSE. Electric meters. (Price 8d.)

21,963. DEWEY. Electric railway systems. (Price 8d.)

22,181. ROGERS. Pads for electric cells. (Price 8d.)

22,473. DREVS. Electrical heating apparatus. (Price 6d.)

COMPANIES' MEETINGS & REPORTS.

Newcastle and District Electric Lighting Company (Limited).

The fifth ordinary general meeting of this Company was held on Monday; Mr. J. D. Milburn, Chairman of Directors, presiding.

In their annual report the Directors congratulated the shareholders on the fact that the prospects of the Company continue good. The installations connected to the mains during the year were equal to 4,000 ten candle-power lamps, bringing the total up to about 11,000, and 206,017 units of electrical energy had been supplied. The Company maintains amicable relations with its consumers, and the Directors trust that the consumption may, ere long, increase to a sufficient extent to enable them to recommend a reduction in the price of current. The gross earnings during the year amounted to £1,860. 15s., and after making provision for depreciation account and reserve fund, and writing off £200 from formation expenses, the Directors were able to recommeud a dividend at the rate of 2½ per cent. for the half-year ending December 31st, which, together with the interim dividend paid in July last, made 5 per cent. for the year.

The CHAIRMAN, in moving the adoption of the report, congratulated the Company upon the steady progress which had been made since its commencement. The receipts during the financial year ending December 31st last amounted to £4,796. 18s. 6d., as against nearly £220,000 of receipts by the Gas Company. The first time he addressed them, he, on behalf of the Directors, intimated that the Newcastle and District Electric Lighting Company did not intend to enter into any insane competition with gas. They wished to supply an artistic, healthy, and exhilarating light at a higher price than gas; and they had hitherto steadily pursued this policy with a fair share of prosperity for themselves, and with the result that, instead of doing harm to the Gas Company, its business had actually increased. They had, therefore, actually exhilarated the Gas Company; for the lighting of the City, whether by gas or by electricity, was never before so efficiently and so well done as at present. In electricity they represented the leading energy of this age, and the Directors would not be content until the Company was doing a fair share of the lighting of the City. Not only would they occupy themselves with the production of energy for lighting purposes, but they would cultivate

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its use for motive power. He was convinced that as soon as they were able to show the Directors of the local tramways any advantage in the use of electricity—especially on such horse-killing places as Westgate Hill—they would not be slow to adopt it. Electric motors would also be found useful for the propulsion of machinery in its manifold uses, and he thought something more might be done by them to encourage the adoption of electric motors. The use of their plant, or a large proportion thereof, during the daytime would considerably reduce the cost of production, and render remunerative to the Company the day hours as well as the night hours, upon which they had chiefly to depend for revenue. The Directors were fully alive to the interests of the public, and so soon as the business of the Company had attained sufficient volume, and the cost of production be reduced, they would recommend a reduction in price, and so bring the use of electricity into still greater popularity. No one who had once used the electric light had any inclination to go back to gas lighting. Coming to the results of the recent year's work, he (the Chairman) said that during the past year lamps equal to about 4,000 10 c.-p. lights had been connected to the Company's mains, and during the same time 15,610 yards of cable had been laid, and 2,439 yards of main and branch piping. The 6in. main pipe, which at the commencement of the Company's operations was laid in Forth Banks, had been filled in with cable, and in view of the demands which were being received for supply of current it had been found necessary to commence laying another 6in. main.

Mr. J. B. HALLIDAY seconded the motion.

The CHAIRMAN, before putting the resolution, reminded his hearers that a great deal of their success was due to the efficient management which had been bestowed on the company by the scientific staff. With a gentleman so well versed in electricity as Mr. Parsons at their head, and officials like Mr. Hunter and Mr. Patterson, there was no wonder that good progress was made.

The report was adopted unanimously, and a vote of thanks to the chairman concluded the proceedings.

British Insulated Wire Company (Limited).

The first annual meeting of the shareholders of this Company was held in Liverpool on the 10th inst.; Mr. Marriner Briggs, Chairman of the Directors, presiding.

The Directors' report contained the following:—

"The greater part of the machinery has been delivered and erected, and the Company has commenced to manufacture cable.

"In August last the Company had the opportunity of acquiring the valuable patents for the manufacture of electrical mains and conductors of Mr. S. Z. de Ferranti, whose inventions and discoveries in electrical science are so generally known and so highly esteemed. At a special meeting the purchase was resolved upon, and an increase of the Company's capital by £50,000 duly sanctioned On the completion of the agreement for purchase Mr. Ferranti joined the Board, and his practical knowledge and experience have already proved of great value. Lucrative orders have been offered for some time past, and might perhaps have been successfully executed; but seeing that the process is an entirely new one in this country, the Directors have thought it the prudent course even to refuse orders until the machinery and testing apparatus had been thoroughly tried, and the delivery of perfectly sound material could be guaranteed. This became possible only since the beginning of this year, and the Directors have every reason to believe that the works will now be fully employed for a long time to come by the orders already given and in sight. The Directors are, of course, not able to declare any dividend, the work of the past year having been entirely devoted to the establishment of the concern.

"During the year the Board has been strengthened by the election of Mr. E. K. Muspratt, J.P., Director of the United Alkali Company, Limited, Mr. Thomas Priestly, Mayor of Bradford, Mr. J. E. Pearson, Director of the Pearson and Knowles Coal and Iron Company, Limited, and Sir David Radcliffe, Director of the Liverpool and Yorkshire Railway Company."

The report was adopted, and the retiring Directors having been re-elected, the proceedings terminated.

India Rubber, Gutta-Percha, and Telegraph Works Company (Limited).

The following is the Directors' report for the year 1891, to be presented at the twenty-eighth ordinary general meeting of the shareholders, to be held at the Cannon-street Hotel, London, on Tuesday, Feb. 23rd, at 12 noon:—

The annexed accounts show the net profit for the past year to be £79,102. 8s. Adding £39,970. 17s. 10d. brought forward, and deducting £20,800 interim dividend paid in July, there remains a disposable balance of £93,273, 5s. 10d. The Directors have added £25,000 of this balance to the reserve fund (raising it to £325,000), and recommend the distribution of a dividend of 10s. and a bonus of 5s. per share, free of income tax, amounting to £31,200, making, with the interim dividend a total payment for the year of 12½ per cent., and leaving £42,073. 5s. 10d. to be carried forward.

The increase in the sales of the Company's general manufactures continues. The cable department has been fairly well employed. More than 1,600 miles of cable have now been manufactured for the South American Cable Company; and it is expected that the whole length contracted for will be made and laid by midsummer. The efficiency of the works and machinery has been fully maintained.

Mr. Scott and Mr. Jarvis, the Directors retiring by rotation, offer themselves for re-election. Mr. Weise is re-eligible as Auditor.

Birmingham Electric Supply Company (Limited).

The following is the report of the Directors of this Company for the nine months ended December 31st last, submitted to the shareholders at the ordinary general meeting of the Company, held at the offices, 14, Dale-end, Birmingham, yesterday (Thursday):—

It will be in your recollection that the accounts presented at the first annual meeting were made up to March 31st last. The alteration of the date of closing the financial year has been adopted to accord with the requirements of the Board of Trade. The accounts submitted herewith show a profit of £713. 16s. 4d., and, taking into consideration the fact that these accounts include the supply during the six summer months, the result cannot but be deemed satisfactory. Of this sum the Directors have applied £351. 16s. 7d. to depreciation reserve account, and recommend that the balance be carried forward to next year's account.

The capital expenditure on buildings, plant, and mains, during the nine months, amounts to £7,761 16s. 7d., this sum including a battery of accumulators, and a fourth engine and dynamo.

The demand for the light has been most satisfactory. The total number of 16 c.p. lamps, or the equivalent, on order at the 31st December, being 5,480, which has since been increased by additions to 6,100. It will be of interest to note the Company have now on their books as customers two hotels, five clubs, four public buildings, two institutions, eleven restaurants, sixty shops, two banks, eight insurance offices, and fifty-six general offices.

From the very ready way in which the light has been taken up, the Directors fully anticipate a large increase in the output of the Station, and in contemplation of this they propose putting down further plant to meet such demand. It is also intended to extend the mains through a portion of the areas allotted to the Company last year.

There still remains of the Company's capital 5,625 shares unallotted, and the Directors consider that the time has arrived when it will be an advantage to the Company that these shares should be taken up. These will at once be offered to the shareholders, and afterwards to the public, at the discretion of the Directors.

Two Directors, Mr. J. F. Albright and Mr. G. H. Johnstone, retire, and being eligible, offer themselves for re-election. The auditors, Messrs. Sharp, Parsons, and Co., retire, and being eligible, offer themselves for re-election.

Westminster Electric Supply Corporation (Limited).

The following report has been issued by the Directors of this Company, and will be presented to the shareholders at the ordinary general meeting of the Company, to be held at the Westminster Palace Hotel, London, S.W., on Wednesday next, the 24th inst., at 11 o'clock:—

In submitting their report and accounts for the year 1891 the Board of Directors are pleased to state that the business of the Corporation is making satisfactory progress; for although two of the stations were not in work until the end of March, and one is still in the builder's hands, the accounts of the past year show a considerable profit upon the working, after making provision for bad and doubtful debts, allowing a fair amount for depreciation, and writing off a proportion of the preliminary expenses and suspense account.

In their report last year, the Board stated that current was being supplied to the equivalent of about 12,000 lamps of 8 c.p. At the present time current is being supplied to 67,500 lamps of 8 c.p., while applications are signed for a further 5,083 lamps of 8 c.p.

The application to Parliament for permission to supply the northern district of Westminster was successful, the Royal assent to the Bill having been given on July 3, 1891.

Mains have now been laid in all the scheduled streets throughout the area of supply, as also in every other street where the expenditure has been justified by the demand for current, both in the original and additional order. The total length of roadway along which mains have been laid up to the present date is about 31 miles. This includes a total of about 123 miles of "ways," along which 89 miles of copper have been drawn.

The Directors have every reason to believe that the Corporation's supply, which has so successfully been given to the Houses of Parliament, will be extended to other Government offices at no very distant date.

Two of the stations of the Corporation which had not been finished at the date of the last general meeting (the Mayfair Station in Davies-street and the Belgravia Station in Eccleston-place) commenced to supply current in March last, and, together with the Westminster Station in Millbank-street, have since been constantly at work. The reports from consumers and others as to the quality of the light supplied have been very gratifying and the increase in the number of applications for current received may no doubt, be ascribed to this fact.

As shown in the report accompanying the accounts the net revenue of the Corporation for the past year is £3,160. 4s. 3d., and this sum the Board consider should be carried forward.

The balance of the authorised share capital, viz.:—£85,235 in 17.047 shares of £5 each was, in accordance with the resolution of the shareholders at the general meeting in February last, issued at par, and was duly subscribed for; many of the original shareholders increased their holdings, and a number of the consumers on the Corporation's circuits invested in the shares. The whole of the authorised capital has now been subscribed, and paid up in full, and it is very satisfactory to the Board to be able to state that there is not a single unpaid call. The Directors have not made any public issue of the debenture capital for which powers are given in the Articles of Association, but have allotted £29,400 in Five per Cent. Mortgage Debentures to applicants, many of whom had applied for ordinary shares of the Corporation.

The auditors, Messrs. Cooper Brothers and Co., retire, and being eligible, offer themselves for re-election.

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NEW COMPANIES, STATUTORY RETURNS, &c.

H. S. CROPPER AND CO. (LIMITED).—This Company was registered on February 9, 1892, with a capital of £15,000, in £10 shares, by Messrs. Hind and Robinson, 8, Stone-buildings, Lincoln's Inn, W.C. The objects are to acquire the business of ironfounders and engineers now carried on by H. S. Cropper, J. Cropper, and S. Thacker, at Minerva Works, Great Alfred-street, Nottingham; to carry on the businesses of mechanical engineers, electricians, suppliers of electricity for the purposes of light, heat, motive power, or otherwise, and manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. Registered without articles of association.

PRINCESS COMPANY (LIMITED).—This Company was registered on February 12, 1892, with a capital of £2,000, in £1 shares, by W. G. MacIvy, 31, Homer-street, Marylebone-road, London, N. The objects are to carry on the business of mechanical and electrical engineers, metal founders and workers, machine and engineering tool makers, and makers of household requisites.

RUSHDEN AND HIGHAM FERRERS DISTRICT GAS COMPANY (LIMITED).—This Company was registered on February 12, 1892, with a capital of £10,000, in £5 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are to acquire the businesses and undertakings of the Rushden Gas and Coke Company (Limited) and the Higham Ferrers Gas and Coke Company (Limited), to light, by means of gas, electricity, oil, or other illuminating power, the streets and buildings of Rushden and Higham Ferrers; to supply heat, light, or motive power generated by gas, electricity, oil, or otherwise. Registered office: The office of Messrs. Simpson and Mason, High-street, Rushden, in the county of Northampton.

REGENERATING BOILER COMPANY (LIMITED).—This Company was registered on February 13, 1892, with a capital of £5,000, divided into 4,000 ordinary and 1,000 preference shares of £1 each, by Jordan and Sons, 120, Chancery-lane, London, W.C. The objects are: "To acquire, work, extend, develop, or otherwise, a boiler for the purpose of generating and regenerating steam, and supplying the necessary material for working and extending the same," and to acquire, work and extend any patent or patents in reference to or relating thereto, and particularly a patent now standing in the name of the vendor (Thomas White, Esq., of Thorpe Hesley, near Rotherham), and all modifications and improvements thereof. Registered without articles of association.

SEA FISHING COMPANY (LIMITED).—This Company was registered on February 13, 1892, with a capital of £10,000, divided into 9,750 ordinary and 250 deferred shares of £1 each, by J. Herbert Farmer, 35, Walbrook, London, E.C. The objects are to acquire, by way of purchase, license, or otherwise, any rights in any inventions for the purpose of fishing by the attraction of the electric light, or for any purpose in connection with fishing; and to buy, sell, manufacture, and deal in plant, machinery, implements, conveniences, &c., connected with the same.

TITANIC STEEL COMPANY (LIMITED).—This Company was registered on February 13, 1892, with a capital of £12,000, in £5 shares, by Jordan and Sons, 120, Chancery-lane, London, W.C. The objects are to acquire and carry on the business of mechanical, electrical, nautical, and general engineers, machine and engineering tool makers, iron, steel, and brass founders, boiler makers, &c., carried on by S. J. Hackney under the style of "The Titanic Steel Company" at Pott-street, New Islington, Manchester.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 29, 1892, was filed on February 6, 1892. The nominal capital is £1,300,000, in shares of £20 each. 60,710 of these have been taken up, all of which have been issued as fully paid. Registered office: Winchester House, 50, Old Broad-street, London, E.C.

ELECTRICITY AND ELECTRICAL ENGINEERING NEWSPAPER COMPANY (LIMITED).—The registered office of the above-named Company (which was registered on November 18, 1890, with a capital of £500, in £10 shares, to establish and work a newspaper, devoted to the interests of electrical science in all its branches), has been removed from 6, White Hart-street, Paternoster-square, London, E.C., to 34, Cannon-street, London, E.C. (filed on January 13, 1892). No returns respecting the shareholders have been filed, but the original subscribers took all the shares.

ELECTROLYTIC CAUSTIC SODA AND CHLORINE TRUST (LIMITED).—The statutory return of the above-named Company, made up to October 29, 1891, was filed on November 24, 1891. The Company was registered on June 15, 1891, with a capital of £10,000 in £10 shares, to acquire and work the British patents, Nos. 2,296 and 2,297 of 1890, being respectively patents for "Improvements in the electrolytic production of caustic soda and other products from their salts," and for "improvements in apparatus to be used for electrolytic purposes." At the time of making-up all the shares had been taken up, 500 of which had been issued as fully paid. Upon the remaining 500 £6 per share had been called and paid. Registered office: 23, Queen Victoria-street, London, E.C.

FIELD'S "M.P." DEVELOPMENT ASSOCIATION (LIMITED).—The statutory return of the above-named Company, made up to the 10th December, 1891, was filed on the 29th December following. The Company was registered on July 28, 1891, with a capital of £100,000, in £1 shares, to acquire and work certain patents (49 in all) which had been or were to be granted in Britain, Belgium, Austria, Brazil, Italy, France, Germany, Luxemburg, New South Wales, New Zealand, United States, Queensland, South Australia, Spain, Switzerland, Denmark, India, Victoria, Norway, and Sweden, to carry on the business of mechanical and electrical engineers electricians, electrical contractors, suppliers of electricity and manufacturers of and dealers in all apparatus, appliances, and things required for or capable of being used in connection with the generation, accumulation, distribution, supply and utilization of electricity. At the time of making-up, 90,000 shares had been taken up, of which £0,000 had been issued as fully paid. Upon the remaining 10,000 the full amounts per share had been called and paid. Registered office (filed on December 18, 1891): 13 and 14, Abchurch-lane, London, E.C.

FOREIGN ELECTRIC DATE AND TIME STAMP COMPANY (LIMITED).—The registered offices of the above-named Company have been removed from 90 and 91 Queen-street, Cheapside, London, E.C., to 20, Bucklersbury, London, E.C.

FREEDMAN BATTERY COMPANY (LIMITED).—The first annual return of the above-named Company, made up to January 2, 1892, was filed on January 7th following. The Company was registered on September 1, 1890, with a capital of £2,000 in £1 shares, to acquire the interests of Charles H. Freedman in an invention, particulars of which were not given, and to develop and bring into public notice the said invention. At the time of making up, 1,865 shares were taken up, 5s. per share called, and all calls paid, amounting to £466. 5s. Registered office: 66, Berners-street, Oxford-street, London, W.

S. Z. DE FERRANTI (LIMITED).—The first annual return of the above-named Company, made up to December, 12, 1891, was filed on Christmas Eve. The Company was registered on June 26, 1890, with a nominal capital of £100,000, divided into 2,000 Five per Cent. Preference and 8,000 Ordinary Shares of £10 each, to carry on the business of manufacturing engineers, contractors for the erection of central stations for the supply of electricity, suppliers of electricity, &c. At the time of making-up, all the shares had been taken up, of which 1,993 preference and 8,000 ordinary had been issued and considered as fully paid. Upon the remaining 7 preference the full amount (£70) had been called and paid. The following was filed on January 26, 1892: "At an extraordinary general meeting of the members of the above-named Company, duly convened and held at the registered office of the Company, situate at St. Benet-chambers, Fenchurch-street, in the City of London, on January 11, 1892, the following special resolution was duly passed: and at a subsequent extraordinary general meeting at the members of the said Company, also duly convened and held at the registered office of the Company on January 26, 1892, the following special resolution was duly confirmed: 'Resolved that Article 11 of the Company's Articles of Association be amended by altering the figure 5 in the third line to the figure 7, thereby providing that the preference dividend on the shares shall be at the rate of 7 per cent.' (Signed) Gerard B. Ince, Chairman." Article 11 amended now reads "Every holder of preference shares or stock shall be entitled to receive, in each half-year, a dividend upon such shares or stock after the rate of 7 per cent. per annum, and no more, out of the profits of each year, before the holders of the ordinary shares or stock shall be entitled to receive any dividend for the same year in respect of such ordinary shares or stock; and if, at the end of any current half-year of the Company's business, there are not profits available for the payment of the full dividend on the said preference shares for that half-year, the deficiency shall be made good as soon as may be out of the profits of the subsequent half-year or years." Registered office: St. Benet Chambers, Fenchurch-street, London, E.C.

W. T. HENLEY'S ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of the above-named, Company made up to January 13, 1892, was filed on January 21st following. The Company was registered on June 2, 1882, with a nominal capital of £100,000, in £1 shares, to acquire from Mr. W. T. Henley certain patents and inventions (particulars of which were not given) relating to the production, supply or employment of electricity, or electrical currents or force, and generally to produce and supply electricity. At the time of making-up 6,918 shares were taken up, the full amount called upon each share and £6,911 paid in respect of calls, leaving £7 unpaid. The sum of £41. 10s. 11d. had been paid in respect of forfeited shares. Registered office: 27, Martin's-lane, Cannon-street, London, E.C.

CITY NOTES, &c.

BABCOCK AND WILCOX (LIMITED).—The Directors have declared a half-yearly interim distribution at the rate of 10 per cent. per annum.

BELL'S ASBESTOS COMPANY (LIMITED).—The Directors have resolved to recommend the payment of a balance dividend of 7s. 6d. per share, which, with the interim dividend paid in July, makes a total distribution for the year of 10 per cent.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended February 14th were £881, as against £728 in the corresponding period of last year, showing an increase of £153. The total receipts to date, from January 1st, 1892, are £5,356, against £4,761, an increase of £595.

THE GÜLCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The following circular has been issued:—"I beg to give you notice that (the Chairman of the Company having only just returned from New Zealand) the fourth ordinary general meeting of the above Company, which stands adjourned until the 18th February instant, will be held at

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the offices of the Company, Battersea Foundry, S.W., at 11 o'clock a.m. on that day, for the purpose only of being further adjourned in order that the accounts, as prepared by the auditor, may be modified, by showing in detail the result of the Chairman's visit to New Zealand upon the year's transactions. Due notice of the further adjourned general meeting will be sent, together with a copy of the accounts,—By order, T. C. MORGAN, Secretary."

NORTHERN ELECTRIC WIRE COMPANY (LIMITED).—The usual dividend of 7½ per cent. has again been declared by the Directors.

REUTER'S TELEGRAM COMPANY (LIMITED).—The final call of £2 on the 3,500 new £8 shares is due to-morrow (Saturday).

SANITAS COMPANY (LIMITED).—The Directors recommend a balance dividend of 5 per cent., making a total dividend for the year of 10 per cent.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY.—The warrants for interest on the preference shares of this Company for the half-year ended December 31st last, at the rate of 6 per cent. per annum, have been posted, and are now payable at the Company's bankers, the National Provincial Bank of England, Bristol.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the two weeks ended February 15th show a decrease of £581 as compared with the corresponding period last year.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Feb. 10.	Price Wednesday, Feb. 17.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Feb. 17. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	16/0	Anglo-American ..... xd	50 51	49 50	5 5 0	Jan., Apr., July, Oct	49¼	49
£2,849,510	Stock	32/0	Do. Preferred ..... xd	89 90	88 89	5 18 0	" "	89½	87½
£2,849,510	Stock	5/0	Do. Deferred	12 12½	12 12½	..	" "	12 5/16	11 7/8
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10¾ 11¼	10¾ 11¼	7 2 3	Mar., June, Oct., Dec	11⅛	10⅞
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	101	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 5	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	153 157	153 157	4 9 2	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine ..... xd	10½ 11½	10 11	7 5 6	February and August	11½	..
6,000	10	10%	Do. Preference 10% ..... xd	16½ 17½	16 17	5 17 8	" "	17	..
12,931	5	2/0	Direct Spanish (£4 paid)	3¼ 3⅝	3½ 3⅝	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	8½ 9½	8½ 9½	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11 11½	11 11½	6 5 0	Jan., Apr., July, Oct	11½	11
400,000	10	2/6	Eastern	14⅜ 14⅝	14½ 14⅝	4 8 2	" "	14⅝	14½
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15½	15¼
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107 110	107 110	3 12 9	May and November	109¼	108⅝
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	105 108	105 108	4 12 7	February & August	..	..
250,000	10	2/6	Eastern Extension	15 15½	15 15¼	4 11 10	Jan., Apr., July, Oct.	15½	15 1/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	February & August	107⅝	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900 ..	101 104	101 104	4 16 2	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)....	98 101	99 102	3 18 5	February & August	101	..
180,227	10	1/6	Globe Telegraph and Trust	9⅞ 10⅛	9⅞ 10⅛	5 6 2	Jan., Apr., July, Oct.	10 1/16	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15	14⅞ 15⅛	3 19 10	" "	15	14 13/16
150,000	10	5/0	Great Northern	19 19½	19 19½	4 7 2	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106 109	106 109	4 11 9	March & September	..	..
17,000	25	12/6	Indo-European	41 43	41 43	5 16 3	May and November	42	41½
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	7½ 8	7½ 8	5 3 2	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	115 120	115 120	5 0 0	" "	..	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	101 104	101 104	4 6 7	March & September	..	..
30,000	10	2/0	West Coast of America	4 5	4 5	..	January and July ..	4 1/16	4⅛
£150,000	100	8%	Do. Debentures 8% 1902	101 105	101 105	7 12 5	June and December	..	..
88,321	10	1/0	West India and Panama	1⅝ 1⅞	1⅝ 1⅞	..	" "	1⅞	..
34,563	10	6%	Do. 6 per Cent. 1st Preference.....	9½ 10	9½ 10	6 0 0	May and November	10	9¾
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8½ 9½	8½ 9½	6 6 4	" "	..	..
67,007	15	6/0	Western and Brazilian	10¼ 10⅝	10¼ 10⅝	7 2 10	" "	10¼	10⅛
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6½ 6¾	6½ 6¾	5 7 3	" "	6¼	6⅜
30,364	7½	7/6	Do. 5 per Cent. Deferred	4 4½	4 4½	..	" "	4⅛	4 1/16
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	101 104	101 104	5 15 5	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910..	101 104	101 104	5 15 5	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance. ..	⅜ ½	⅜ ½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16 ⅛	¼ ⅜	6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅛ 4⅜	4⅛ 4⅜	6 17 2	June and December	4⅜	4¼
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13 13½	13½ 13¾	4 7 3	" "	13¾	13 1/16
15,000	10	6%	Do 6% Cumulative 2nd Pref.	11½ 12½	11¾ 12½	4 16 0	" "	12½	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	104 107	104 107	4 4 1	January and July ..	106	105½
58,000	5	1/0	United River Plate	1 2	1 2	..	" "	1 1/16	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock.....	80 90	80 90	5 11 1	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£6 paid)	6 6½	6¼ 6⅜	..	..	6 1/16	6⅛
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	.. ..	.. ..	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5⅞ 6¼	5⅞ 6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5⅞ 6¼	5⅞ 6	..	January and July ..	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2⅝ 2⅞	2⅝ 2⅞	..	March	..	..
10,000	£5	3½%	Do. (fully paid)	4⅜ 5	4⅜ 5	..	March	..	..
111,000	5	..	London Electric Supply	1 1¼	1 1¼	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8½ 9	8½ 9	..	..	9	8¾
6,318	10	..	Notting Hill Electric Lighting (fully paid)	5 6	5 6	..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8¼ 8⅝	8¼ 8⅝	..	..	8⅝	8¼
7,900	£5	7%	Do. 7% Preference	7¼ 7⅝	7¼ 7⅝	..	..	7 1/16	..
42,853	5	..	Westminster Electric Supply (fully paid)	6⅝ 6¾	5⅞ 6¼	..	..	6⅝	5¾
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/8	Brush Electrical Engineering	3¼ 3⅜	3¼ 3⅜	..	..	3⅜	3 5/16
69,996	2	6%	Do. 6 per Cent. Preference	2 2¼	2 2¼	5 7 7	..	2¼	2 1/16
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 6	5½ 6	5 16 8	January and July ..	5⅝	5 11/16
17,139	5	17%	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	5⅜ 6¼	5⅜ 6¼	..	—	6	..
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅛ 3⅜	3 3¼	..	—	3¼	3
20,000	5	..	Fowler-Waring Cables (£4 paid).....	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works ..	21½ 22½	21½ 22½	4 8 11	February & August	22¼	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 106	4 4 6	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3¼ 4½	3½ 4½	..	..	..	..
11,334	£10	8/0	Do. Preference	8 9	8 9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛ ⅜	7/16 9/16	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	3¾ 4¼	3¾ 4¼	9 12 6	May and November	4 3/16	4
36,250	12	12/0	Telegraph Construction and Maintenance	43 45	44 46	5 4 9	March and July.....	45½	44½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100 103	100 103	4 17 1	January and July ..	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)..	1⅝ 1⅞	1⅝ 1⅞	5 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid).....	3½ 3¾	3½ 3¾	10 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	—	—	..	..
50,000	£10	—	City and South London Railway	2½ 3½	2½ 3½	..	—	..	..

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THE ELECTRICIAN:

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NOTES.

By a formal announcement in the *London Gazette* of Tuesday last the scientific world is informed that it has lost a Sir William Thomson, and has gained a Baron Kelvin, of Largs, in the county of Ayr.

The speeches to which shareholders of flourishing companies are annually treated have generally the merit of lucidity, though they may lack variety. On the other hand, when a company prospers not, it is strange how little real information is given in a lengthy discourse. The shareholders of the Westminster Electric Supply Corporation are, therefore, fortunate in having heard on Wednesday afternoon a statement at the same time lucid, interesting, and free from undue vaticination as to future profits.

In February last the Westminster Company had only some 13,000 lamps connected to its mains; to-day it has no less than 72,000. Its plant, however, is well ahead of the demand, being capable of generating sufficient current for 130,000 lights; while, without enlarging the station buildings, space could be found for an additional 165,000 light plant, and without purchasing more land another 295,000 lamps could be supplied. No wonder, therefore, the chairman hails a London fog as a godsend, and gloats over the fact that the Christmas fog sent up the weekly income by 50 per cent., viz., from £800 to £1,200. For our own part, however, we hope to see the day when the Westminster Company, owing to the strain upon its ultimate resources, will anathematize a week of darkness almost as much as the rest of the community.

Mr. Powell, who temporarily occupied the chair, paid a well-deserved tribute to the energy and ability of the Company's engineer, Prof. A. B. W. Kennedy; and influenced, it may be, by the latter's references to the possibility of Mr. Nikola Tesla's experimental investigations reducing the value of the plant at Millbank, Eccleston-place, and Davies-street to that of iron-scrap, he made what our American friends would call a most "conservative estimate" as to future profits. However, taking the revenue per lamp, wired at only 10s. per annum, and supposing that no more are connected to the mains for the next twelve-months, the gross receipts may be expected to considerably exceed 10 per cent. upon the total capital expenditure, so that it is not too much to anticipate a bright future for this well managed Supply Company.

The rivals of the House-to-House Company sincerely regret the breakdown which happened last week. This Company has declared, by-the-bye, that it has neither rivals nor competitors. It takes two to make a quarrel, but a brisk rivalry and keen competition may apparently be carried on in a one-sided fashion. Be this as it may, a stoppage of supply from any of the metropolitan stations cannot but shake the confidence of the public and do temporary harm to the other companies. It would be a much greater misfortune if the electrical arrangements had been inadequate, and it is some comfort that the failure was only due to the fracture of a steam-pipe. Advocates of the low-pressure system naturally say that if batteries had been used a district would not have been thrown in darkness; but it appears that the common-sense precaution of independent supply or a ring main pipe, as adopted in all well-designed stations, would have confined the accident to one engine. We understand that the engines to which steam could be supplied after the breakage could not supply the whole load, and that a considerable part of the system was cut off until the next day, although the average per lamp may be taken as only one hour. We have heard various reports, but will merely give the information sent in reply to our inquiries by Mr. Gay:—

"We have not at any time since the station was first built had any breakdown of the electrical apparatus, but on Tuesday night last one of our steam-pipes which has not yet been duplicated developed a small fracture, and we thought it not wise to run any risk; we therefore cut off the supply to a portion of the lights. The total period during which this portion of the lights were out averages about one hour, and of course a large number were not disconnected at all."

Major Cardew's method of measuring insulation resistances, described in the present issue, appears to be an excellent one, and is certainly sensitive enough when as many as 400 cells are used for charging the quadrants. The deflection of the electrometer is proportional to the potential of the cells, and also to the difference between the voltages absorbed by the two resistances which are being compared; and it can be calculated that an electrometer, which when used idiostatically will just detect a potential of 10 volts, will be sufficiently sensitive to determine the insulation resistance to one part in 1,000. As, however, high-resistance galvanometers are much more common and much more satisfactory instruments to deal with than electrometers, it is worth while

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pointing out that an electrometer is not necessary in Major CARDEW'S method, and that, in fact, the measurement can be made much more sensitive by the use of electro-magnetic instruments. An electrometer can always be replaced by a high-resistance galvanometer and a condenser, so that if in Major CARDEW'S arrangement the middle of the battery be joined to the junction of the resistances through a condenser and a Morse key, the latter being arranged to discharge the condenser through the galvanometer, the method will work equally well, and will need fewer cells than when an electrometer is employed.

THE question which was raised at the last meeting of the Physical Society about the proposed high grade of membership called "Fellows," and another class besides ordinary members, "in the shape of students," suggests that most scientific and technical societies range themselves, like transformers, into two kinds—the close and the open. The Royal Society is very properly at the head of the "close" type. The term "candidate" for election as Fellow of the Royal Society is only formal. Practically, no application is made as in other societies; but individuals are nominated by the Council, and when their names, as "selected candidates," are announced, they are for all practical purposes elected. No system could be better devised for maintaining the unrivalled position of the Royal Society. On the other hand, the qualifications for membership of the Royal Institution, Society of Arts, Physical Society, and Institution of Electrical Engineers, are equally a matter of form, for practically none are required. No distinction, under these circumstances, is carried by the fact of membership, but what may be lost to a society in prestige is amply compensated by an increased sphere of usefulness. An efficient council can take care that this freedom does not result in quantity at the expense of quality. When once the qualification is dropped or allowed, as in the case of the Institution of Electrical Engineers, to become practically nothing, a large number of members ought to support the Society, which, with so much to choose from, should have much to give. There is hardly room in any one branch of knowledge for more than a single society of the "close" type, and it seems difficult to combine the benefits which such a body affords with the wide range of the less exacting societies.

A NOTE which appears in our "Notes" column is another indication that the Chicago Exhibition is to be an excuse for the holding of innumerable Congresses. The promotion of the "progress, prosperity, unity, peace, and happiness of the world" is all very well in its way, but it is more retarded by one single act such as the MCKINLEY tariff than it is advanced by a deluge of congressional tall talk. Engineers, electrical and other, will be gathered together next year at Chicago from all points of the compass; a well-organised reception and guidance committee, and a convenient *rendezvous* for members of the same profession, would be far more appreciated by them than crowded meetings in stuffy halls, even if these miscellaneous gatherings are grandiloquently styled Congresses.

The Paris and New York Telegraph Company.—The cable of this Company is at present interrupted.

Subways.—The London County Council's Subways Bill was read a second time in the House of Commons on Monday.

"Die Elektrizität."—A new semi-monthly periodical with this title, the organ of the Leipziger Elektrotechniker-Verein, has just made its appearance.

The Oye-Fanoe Cable.—The 1891 Franco-Danish cable running between Oye and the island of Fanoe is interrupted some 45 miles from the coast of France.

Cambridge.—The Town Council last week adopted a Committee report which means the virtual abandonment of the idea of promoting the electric light by the Corporation.

Inter-urban Telephony.—The Dublin-Belfast (100 miles) telephone trunk wire has been completed, and within a few weeks Belfast will be able to speak with the Irish metropolis.

Submarine Navigation.—A new submarine vessel propelled by electricity, has been designed by Signor Pullini, of the Italian Navy, and is being constructed by that Government at Spezzia.

Belfast.—The meeting of the Gas Committee of the Corporation has arranged that a deputation representing the Corporation should proceed to London to inspect the Electrical Exhibition at the Crystal Palace.

Telegraphic Communication with Lighthouses.—Mr. Penrose Fitzgerald proposes, on going into Committee of Supply, to move a resolution with reference to telegraphic communication between lighthouses and lifeboat stations.

Royal Institution.—Mr. F. T. Piggott will deliver his Friday Evening Discourse on "Japanesque," on March 11th, in place of Prof. Oliver Lodge, who will give his lecture on "The Motion of the Ether near the Earth," on April 1st.

Personal.—Mr. Ernest G. Pink informs us that he no longer holds the post of Chief Engineer to the Electricity Supply Company for Spain, and that he has in no way been responsible for the working of the Madrid central station since November 16, 1891.

The Uses of Petroleum in Prime Movers.—Prof. William Robinson, of Nottingham, is about to deliver a course of four Cantor lectures on this subject, before the Society of Arts, on successive Monday evenings, the first lecture being on Monday next, 29th inst.

Crystal Palace Engineering Society.—On Tuesday last week a Paper was read and discussed on "Electricity as a Motive Power on Tramways and Railways," by Alfred H. C. Olley, Student, to the above society, in the new Lecture Hall of the Engineering School.

Thunderstorms.—In the West of England the recent snowstorms were in many places accompanied by thunder and lightning. At Hamerton (Devon) a carpenter, whilst on his way to his work at the Devon Great Consols Mines, was struck by lightning and killed.

Electric Traction.—At the last Town Council meeting at Mährisch-Ostran it was decided to invite tenders up to April 15th for building a tramway line, 4½ miles long, between that town, Prziwos, and Witkowitz, and also for the supply of light and power in the three places.

A "Drehstrom" Glow Lamp.—According to the *Zeitschrift für Elektrotechnik*, Messrs. Siemens and Halske have patented an incandescent lamp for use on rotating current systems. This lamp has terminals corresponding in number with the number of different phases employed.

The Electrical Utilisation of Water Power in the Tyrol.—A power station is projected on the Adige and the Toll in the Tyrol. Water power to the extent of some 10,000 horse-power is available. Light and power will be distributed in the towns of Bolzano and Merano, which are going to share the cost of the scheme.

Aberdeen.—A sub-committee of the Gas Committee of the Town Council, appointed in connection with the proposal to light the town by electricity, have resolved to obtain informa-

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tion from Bradford, Liverpool, Bournemouth, Newcastle, and other places where the electric system of lighting has been in existence.

American Institute of Electrical Engineers.—With the object of calling attention to the work of this Institute, a pamphlet has been issued, giving an historical sketch of its organisation and work. Accompanying the pamphlet is an application form for admission to the Institute and a list of the officials and members.

Cable Extension.—A contract has been signed between the Portuguese Government and the Telegraph Construction and Maintenance Company, for laying a submarine cable between Portugal and the Azores, connection to be made between each of the islands of Madeira, San Miguel, and Fayal. The work has to be completed within a period of twelve months.

Bremen.—The deputation, the senate, and the citizens have at last made up their minds to accept the tender of Siemens and Halske for the erection of a central station for 20,000 lamps. The sum voted is £95,000. A 3,000-H.P. plant and a battery of Tudor accumulators for 8,000 lamps will be laid down. The three-wire mains are planned for 20,000 lamps.

The Berliner Electricitätswerke.—From this Company's annual report it appears that the number of consumers increased during their last financial year by 50 per cent.; the number of lamps connected rising during the same time from 74,959 to 104,100. The Company also experiences a good demand for current for power purposes. A dividend of 9 per cent. was declared.

Obituary.—The death is announced of Mr. Neil Bannatyne, a Director of the India Rubber, Gutta Percha and Telegraph Works Company and of the Cuba Submarine Telegraph Company. Mr. Bannatyne died at his residence, 15, Earl's Court-square, on the 15th inst. He had been connected with these two companies for twenty-two years.—The death, on the 11th inst., is also announced of Mr. Alfred Marshall, Chairman of the West Coast of America Telegraph Company.

The "Sir William Siemens" Laboratory.—On Friday afternoon last Sir William Thomson opened the Electrical Engineering Laboratory which has been founded at King's College by Lady Siemens, in memory of her husband, Sir William Siemens. The cost of the laboratory has been entirely defrayed by Lady Siemens, who has also placed at the disposal of the council of the college a sum of money to maintain it in proper efficiency. The apparatus of the laboratory includes at present a steam-engine and boiler, direct and alternate current dynamos of latest design, and a full equipment of instruments of the newest construction. The laboratory, it will be remembered, is in charge of Dr. John Hopkinson.

Mr. Nikola Tesla.—On Friday last, says our Paris Correspondent, Mr. Nikola Tesla repeated his magnificent experiments with alternating currents of high frequency before the Société Française de Physique and the Société Internationale des Électriciens. Unfortunately, Mr. Tesla confined himself to demonstrating by a series of very beautiful experiments (which it is unnecessary to describe, since they have all been published some time ago in the English technical journals) the numerous phenomena to which these currents may give rise, without either alluding to his methods of obtaining these high frequencies, or giving the audience the benefit of his own personal explanation of the phenomena. An exchange of ideas on the question would, however, have been much appreciated. Mr. Tesla was, nevertheless, warmly congratulated on his experimental skill.

Lightning Statistics.—For some time past M. Évrard has annually published in the *Bulletin de la Société Belge d'Electriciens* a statistical *résumé* of the lightning strokes which have occurred in Belgium. These statistics are very exhaustive, and have proved of considerable scientific and practical value. The Société Belge d'Electriciens are, therefore, agitating for the creation of a permanent Lightning Rod Commission, to collect, edit, and publish these statistics as hitherto, and to study the whole theory of the subject in the light of actual phenomena. The Société ask that M. Lancaster, who is at the head of the Belgian meteorological service; M. Lambotte, telegraph engineer; and M. E. Lagrange, secretary of the Société, should be members of the Commission. The Académie Royale having given the proposal every support, it is expected that the Commission will be formed.

An American Street Railway Engine.—There has, says the *Electrical Engineer* of New York, been recently installed in the power house of the Buffalo Railway Company the first of two engines which have been specially designed for electric railway work. The engine is of the vertical 2-crank compound condensing type, with cranks at 90 degrees to facilitate starting and stopping. It drives two Edison railway generators by means of two 24in. belts from the fly-wheel of the engine, which is 12ft. in diameter and weighs 16 tons. The total weight of engine is about 40 tons. The engine runs at 138 revolutions, with a piston speed of 600ft. per minute; on 125lb. initial pressure the engine develops 450 H.P. The speed is regulated by means of a centrifugal shaft governor. Operated in this manner the speed varies only by ½ revolution in a change of load from 360 to 700 amperes.

The Cologne Municipal Central Station.—The number of houses connected to the municipal network, says our German correspondent, is now about 150, with a total of 20,000 8-c.p. lamps installed. The maximum demand in December and January was equivalent to about 11,000 8-c.p. lamps. The increasing demand has made it necessary to order a third 500 H.P. steam dynamo from the Helios Company of Cologne and Messrs. Sulzer. Only 3 per cent. of the lamps installed are in private houses, the others being chiefly in shops, and a few hundred also in public buildings. To encourage the public the charge of 1d. per 100 watt hours has been reduced, in such a manner that of two consumers with a different number of lamps installed, but with an equal monthly consumption, the one with the smaller installation will have the benefit. The consumer may also now instal as many lamps as he likes without being bound to burn them a certain number of hours yearly; at first he had to guarantee 300 hours per lamp installed. The horizontal Sulzer engines illustrated in *The Electrician*, November 13th, 1891, p. 35, requires only 2·2lb. of coal per I.H.P.H. The financial aspect of the station is most encouraging.

The Recent Magnetic Storm.—The recent magnetic disturbances were by all reports widespread and unusually severe. M. Moureaux informed the Académie des Sciences, at its last meeting, that "An extraordinary magnetic disturbance, such as has not been observed for ten years, surpassing in its intensity that of November, 1882, was registered on the magnetograph of the Parc Saint-Maur Observatory on February 13th and 14th. It began suddenly about 5:45 a.m. on the 13th by a simultaneous increase of the declination and horizontal component, and a corresponding decrease of the vertical component." As at Kew, the curves went off the scale. The disturbance ceased about 5 p.m. on the 14th. The total variation of the declination was more than 1° 25′, and the horizontal and vertical components varied from their normal values by $\frac{1}{3\cdot7}$ and $\frac{1}{3\cdot8}$ respectively. The curves at Perpignan, Lyons, and Nantes show that the phenomenon began at the same time, and the variations at the four stations are so similar that the records of the instruments are as superposable as tracings of a drawing. The disturbance, says M. Moureaux, is clearly distinguished from all others recorded at the Parc Saint-Maur Observatory by the excessive variations of the vertical component.

The Protection of Buildings from Lightning.—A Paper on this subject was recently read before the Society of Architects by Mr. Alfred Hands. Between April 1st and October 31st, 1891, the following buildings were stated to have been struck by lightning, and more or less damaged:—Churches and chapels, 21; residences, 114; farmhouses and ricks, 28; hotels and public-houses, 9; schools, workhouses, and other institutions, 7; factories, mills, and other business premises, 9; chimney shafts, 5; railway stations, 3; military buildings, 2; telegraph and post offices, 2; stables, 3; race stand, 1; athletic pavilion, 1; lifeboat house, 1. The loss of life by lightning during the same period includes:—Men and women, 18; cattle, 94; horses, 35; sheep, 153. Mr. Hands is of opinion that quite 70 per cent. of the conductors now in England are in an unsatisfactory condition. In stating that at least 70 per cent. of the lightning conductors in England are in an unsatisfactory condition, Mr. Hands does not include

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the magazines, &c., of the War Department, the majority of which are provided with extensive systems of conductors, which are tested annually and kept in good order. The list of buildings damaged by lightning, consisting of 206, is not by any means a comp'ete one, as it only includes cases extracted from the public Press.

Telephonic Progress in Austria.—An occasional correspondent sends us the following particulars with regard to telephonic matters in Austria:—The telephone continues to make steady progress. The subscribers in Prag, Trieste, Lemberg, Graz, Czernowitz, Pilsen, Reichenberg, and Bielitz, have increased to 3,624, and in Vienna to 5,200, and in the 47 small exchanges opened by Government since 1889 to 1,716, a total of 10,540. In Vienna the majority of the lines are underground looped lines; reckoning these as single, there are now 12,250 miles laid, and 9,500 being laid. The total telephonic wire mileage for the country amounts to 25,800. The cables used in Vienna are 1mm. copper wire, covered with 1mm. gutta-percha. There is only one exchange in Vienna into which now 5,000 looped lines run, and about 3,000 more are being run into it to provide for future extensions. The most distant subscriber is some four miles from the exchange. Interurban trunk lines have also been pushed forward; there are now 23, of which the most important are:—Vienna-Prag (direct), 191 miles; Vienna-Prag (*viâ* Brünn), 219 miles; Vienna-Brünn (direct), 79 miles; Vienna-Budapest (three lines), 25 miles; Prag-Tilschen, 72½ miles; Prag-Reichenberg, 70 miles. The Vienna-Trieste line will be commenced in March *viâ* Graz; it will be 313 miles long.

Chicago Exhibition.—The British railways have undertaken to carry goods for British exhibitors at the Chicago Exhibition, to and from the port of shipment, at half rates. The American railways will charge their usual rates to Chicago, but will bring back the goods free at the close of the Exhibition. Many of the principal steamship companies have reduced their rates considerably, and will take freight for the Exhibition at 11s. per ton. Many of them have also consented to adopt a reduced passenger tariff for exhibitors and their *employés*, certified as such under the authority of the Royal Commission.——Among the various Congresses which are being promoted by the "World's Congress Auxiliary" is an International Congress of Engineers. Its organisation has been entrusted to a special committee, assisted by an Advisory Council, of which Mr. James Dredge, Mr. W. H. Maw, and Sir Benjamin Baker are members. It is expected that the Engineering Congress will take place in the month of July or August. The Congress is to begin with a joint meeting, and it is then to be divided into seven general divisions, as follows:—(A) Civil Engineering, (B) Mechanical Engineering, (C) Mining Engineering, (D) Metallurgical Engineering, (E) Electrical Engineering, (F) Military Engineering, (G) Marine and Naval Engineering. Voluntary Papers are to be solicited from engineers throughout the world. Some of the objects of this organisation are, we are told—(I.) To provide for the proper presentation of the intellectual and moral progress of the world, in connection with the Columbian Exposition of 1893, in a series of World's Congresses under the auspices of the Auxiliary, with the assistance of the leaders in all the chief departments of human achievement. (II.) To bring all the departments of human progress into harmonious relations with each other in the Exposition of 1893; to crown the whole glorious work by the formation and adoption of better and more comprehensive plans than have hitherto been made to promote the progress, prosperity, unity, peace, and happiness of the world; and to secure the effectual prosecution of such plans by the organisation of a series of world-wide fraternities through whose efforts and influence the moral and intellectual forces of mankind may be made dominant throughout the world.

Electric Current for Medical Purposes.—In a recent article in the *Lancet*, Dr. W. S. Hedley briefly discusses the precautions necessary when using current "from the main" for electro-medical purposes. If the current supplied, he says, be the continuous one, an adjustable rheostat is all we require, provided we keep a milliampere meter, or at least some current measurer, in circuit. Such rheostat ought to possess quite 50,000 ohms resistance, working down by steps not exceeding 1,000 at a time to zero. The objection to such an arrangement is that in the event of the electromotive force in the mains rising suddenly from some disturbing cause, the safety-fuse may act, and (automatically cutting off the current) give a more or less violent shock to any patient under treatment at the time. Further, that if, as sometimes happens, the fuse is somewhat sluggish in its action, a current considerably in excess of that intended may pass through the patient for the instant previous to the automatic breaking of the circuit. In a well-regulated current supply, such as that now provided by our English electric light companies, the risk of accidents of this nature, Dr. Hedley thinks, is very small. Still, it is well to bear in mind that in using a current from an electric light main we must be prepared against an unexpected and undesirable *increase* of power, instead of the unexpected, undesirable, and vexatious *decrease* of power which frequently accompanies battery currents. Dr. Hedley then refers to the use of alternate currents, and the ease with which they lend themselves to various transformations. He also points out that the varying currents obtained from the main of an electric light supply company do not vary so abruptly as those generated by an ordinary medical induction coil, and their medical *qualities* are, therefore, not quite the same. The current from an alternator is, as Dr. Hedley correctly states, "*comparatively* smooth and wavy," though it is scarcely of the pure sinusoidal order that he assumes. Dr. Hedley concludes that whilst it is clear that electric light circuits cannot be used for medical purposes without the strictest measures of precaution against the influx of strong currents, there is also good reason to suppose that efficient protection can be secured by the adoption of suitable methods.

The Buffalo (N.Y.) Arc Light Stations.—The National Electric Light Association holds its semi-annual meeting at Buffalo this week, and the *Electrical World* of February 13th contains a sort of electrical guide-book to Buffalo, compiled by Mr. Carl Hering. The following particulars relating to the Brush arc-light central station are interesting. The station has at present a capacity of 1,000 lights, and is run by a single tandem-cylinder condensing engine of the Reynolds-Corliss type. The coal consumption is 1·93lb. per light per hour. At present one Weston, one 100-light Wood, and eighteen 60-light Brush dynamos are in use. The Brush 60-lighters are, however, considered too small, and twelve 100-light 5,000-volt Wood dynamos are to be added. The longest circuit is 21 miles in length. The entire station is run by five men, viz, two firemen, one engineer, one oiler and one dynamo-tender. A recent addition to the station is a line of compressed air piping. This compressed air performs the double function of blowing out commutator "arcs" and cleaning the dynamos. An interesting feature of the Thomson-Houston station at Buffalo is the use of the exhaust steam for heating buildings in the vicinity. Formerly the steam was discharged directly into pipes, which, however, necessarily caused a back pressure. They are replacing this system now by the Bernard vacuum system, in which there is a condenser at the return end. The advantage of this is that there is no back pressure and that they get the benefit of the hot water from the return pipes, which, however, is limited to that from the buildings which are higher than the station, as the water returns by gravity; in low buildings the water is discharged. The disadvantage of the vacuum system is that it requires a return system of piping. The charges are 25 to 30 cents per year per square foot of radiating surface of the heater. They are very well satisfied with the system and find it an excellent investment. They limit the amount to that which they can supply with the exhaust steam only. They are about to introduce a 5lb. cold air blast service at this station also, the escape being directed to the armature. Our readers must not imagine that this is for the purpose of blowing out the spark on the commutator; for Mr. J. Stanford Brown wrote (*The Electrician*, December 4, 1891) to say that the air blast of the Thomson-Houston dynamo was never intended for the purpose of blowing out the spark, but that the idea was "simply to blow a cold blast of air, as it were, to drive that spark away," &c. This important distinction was lost sight of by Prof. S. P. Thompson and others.

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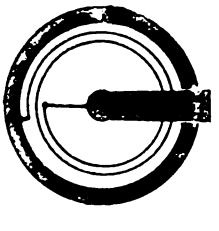
ELEMENTARY IRONLESS DYNAMO.

BY S. TOLVER PRESTON.

The mention of the idea of an ironless dynamo in the Physical Society's report in *The Electrician* of January 29th, makes me think of a suggestion in a Paper of mine in the *Philosophical Magazine* for July, 1871. I give in the accompanying sketch an arrangement which would seem (query) the most elementary form conceivable, more so than that proposed in the above Paper. The chief idea therein (which, if not new, was at least original) was that the machine should—after the instantaneous introduction of an initial current* into the circuit by the temporary approach of a magnet, &c.—keep up by the reaction of its moving parts a current: in other words, that electricity or current should be generated out of *mere motion*.

The apparatus consists of a metal ring (shown black in the diagram) simply used for a brush or radial arm to slide on. One end of a short spiral of wire is attached to the ring outside, the other end to a central pivot or axis carrying the radial arm or brush. This is all. The brush can spin round like the spoke of a wheel in sliding contact with the surface of the ring. It may be an interesting question as to what is the limiting velocity required to keep up a current, in view of the simplicity of the apparatus.

The machine resembles in principle a known form of motor for illustrating the mutual reaction of currents; and if a voltaic element were introduced into the circuit of the machine (by interrupting the spiral at any point and attaching screw terminals), the radial arm could of course be made to rotate by the action of the magnetic lines of force of the spiral, which the arm cuts transversely.



If (conversely) the radial arm be forced to revolve in the direction opposite to that in which the current tends to drive it, the current will be intensified, or mechanical energy converted into current. By an adequate increase of velocity of impressed spin, it is evident that the current generated by the reaction of the moving parts of the circuit upon each other will enormously exceed that of the voltaic element, which may consequently be shunted out of the circuit without making any practical difference in the current, which the machine evolves *solely out of motion*. But it appears a limiting velocity is required to keep it going. We may observe that the machine represents practically a self-charging dynamo on the Siemens-Wheatstone principle, but carried a step further on account of the entire absence of magnet or iron. What is called the Siemens-Wheatstone principle, whereby a current from a revolving armature is turned into the coils of the electro-magnet to augment its magnetism and so react again (strongly) on the armature—is then analysed, a motor reversed (*i.e.*, driven instead of driving), or nothing more, as will probably be admitted. In fact, without altering the arrangement of the connections, put a voltaic battery into the circuit of such a machine, and it revolves. Leaving the battery in, drive the machine in the reverse direction to that in which the current twists it, and we raise current to any intensity; so that the machine is a reversed motor. Without changing the connections, merely short-circuit the battery, and the current derived from rapidly reversing the machine remains practically the same. The above discovery (ingenious as it is admitted to be) amounted to observing that when a motor is itself driven instead of driving something, the residual magnetism in the iron will render superfluous a voltaic battery to start the machine into electric activity.

* This is, of course, parallel to the way in which electrostatic influence machines are excited.

The introduction of a voltaic cell into the circuit of our elementary machine (without iron) was only imagined for the purpose of illustration. Theoretically, all that is necessary, of course, is to approach to the spinning apparatus a magnet or a separate current for an instant. The initial current induced in the revolving radial arm is then immediately intensified by the reaction of the moving parts of the circuit upon themselves (according to the compound interest law), increasing the magnetism of the spiral, and so the effect *ad infinitum*, i.e., dependent on the velocity, as we may remark. If the speed demanded be impracticably great a purely theoretical interest will attach to the subject. The opposition of centrifugal force or friction, if too excessive, cannot alter the truth of the idea, obviously.

Hamburg, Feb., 1892.

THE D.P. ACCUMULATOR.

Much has been heard of late about the D.P. or Dujardin-Planté accumulator, which is now being regularly manufactured by Messrs. Johnson and Phillips for Messrs. Drake and Gorham, who hold the English patents for the original cell, and the numerous improvements in detail which they have introduced

Unformed D.P. plate.

since this accumulator first came into their hands. Some Dujardin-Planté plates were shown at the St. Pancras Vestry Electrical Exhibition in March last, and attracted much attention; but we were unable at that time to elicit any information with regard to their peculiarities and performance beyond what we could see for ourselves (*The Electrician*, Vol. XXVI., p. 612).

These cells, we are now informed, may be considered to have got beyond the experimental stage, having been in actual commercial use for the last two years. There is a decided tendency, on the part of the leading storage-battery makers, to a reversion to the old Planté type, and the Dujardin plate is no exception to the rule; it is, indeed, essentially of the Planté type, no oxides or salts of lead being used in the course of manufacture. From the accompanying illustration of an unformed D.P. plate, it will be seen that it is laminated in structure, being composed of thin strips of sheet lead built up one above the other, and burnt on to lead supports at either end. Spaces are left between the strips in which oxides are formed, by a modification of the Planté process. A plate of this character obviously offers a large working surface, and is free to expand in a vertical direction. By using very thin strips, a remarkably high capacity per lb. of plate can be obtained, though of course at the expense of other equally-important qualities, such as durability.

The following figures with regard to the capacity, normal rate of charge and discharge, &c., which have been furnished us by Messrs. Drake and Gorham, will be of interest:—The capacity per lb. of plate (both positive and negative) at the standard discharges is about 4·5 ampere hours. This, as we have stated above, can be greatly increased if necessary in special types of cells, such as for tramcar work, &c., by increasing the number of strips in each plate and making them thinner. The normal rate of charge is about ·071 ampere per

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square inch of positive plate, or ·034 ampere per square inch of both plates, or half these figures if the two surfaces of each plate are considered. The normal discharge current is the same. The maximum discharge current per square inch of positive plate is about ·068 ampere per square inch of positive and negative plate, or half these rates if both sides the plates are considered. The normal discharge per lb. of positive plate is at the rate of ·95 ampere, and per lb. of positive and negative plate ·44 ampere. The maximum discharge per lb. of positive plate is 1·9 ampere, and per lb. of positive and negative plate ·88 ampere.

The acid used is the ordinary commercial sulphuric acid at a specific gravity of about 1160. The distance between the plates in the standard type cells is $\frac{5}{16}$in. The sizes of plates in the standard type cells are—positives 9½in. by 9in. by $\frac{5}{16}$in., negatives 10in. by 9in. by ¼in.; the positives being made slightly narrower than the negatives to give them perfect freedom to expand in any direction, thus avoiding all risk of buckling. The plates are connected in the ordinary way by burning them in parallel on to a common lead strip arranged to bolt on to the adjoining cells. The sections are stood on V-shaped bottom blocks leaving a clear space of from 1½in. to 2in. between the section and botton of the cell, for the collection of mud, paste, &c. The capacity of these cells is said to be considerably higher for rapid discharges than that of other types. Discharging the cells at double the list rates only decreases the capacity by about one-third.

On the Continent the leading type of cell is undoubtedly that known as the Tudor, and as the Planté principle enters largely into its construction the following comparative figures are serviceable :—In the D.P. cell we get 2·44, and in the Tudor 1·83 ampere-hours per lb. of total weight of cell of 220 ampere-hour capacity; in the D.P. cell the normal discharge current in amperes per square inch of plate is ·034, in the Tudor ·03.

A battery of D.P. cells was at work throughout the whole of the Naval Exhibition in connection with Lieut. Wells's exhibit, and its performance was satisfactory to him, although the battery worked under exceptionally trying conditions. A special pattern has been designed for central station purposes, and is now to be seen at the Crystal Palace.

THE ELECTRICAL EXHIBITION AT THE CRYSTAL PALACE.

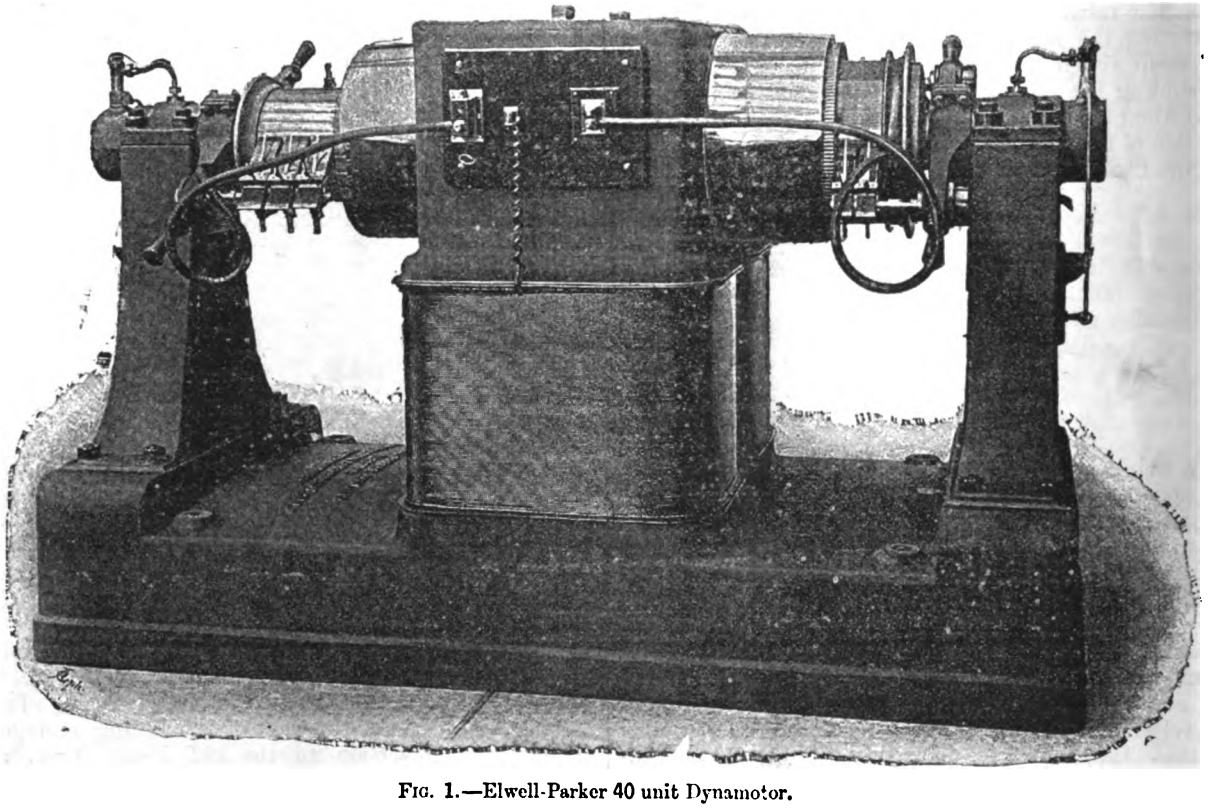

Fig. 1.—Elwell-Parker 40 unit Dynamotor.

The Electric Construction Corporation exhibit an Elwell-Parker continuous-current transformer, which supplies current to various exhibitors. This machine (Fig. 1) is wound to give an out-put at the secondary terminals of 110 volts and 360 amperes, when supplied with primary current from Messrs. Gordon and Co.'s station at Sydenham, at a pressure of 1,000 volts, and run at a speed of 550 revolutions per minute. The efficiency is as high as 91 per cent. with full load, and over 81 per cent. down to one-third load. The bearings are fitted with specially designed oil pump so as to secure continuous lubrication, allowing the machine to be left for lengthened periods without attention. A similar machine to this has been running at the Chelsea Electricity Supply Company's station for the last eighteen months, and recently a second one has been added. The Corporation now have in hand a complete central station for Oxford, where high-pressure continuous current with the Elwell-Parker transformers has been adopted.

Messrs. Woodhouse and Rawson exhibit a large collection of their well-known goods. Among a number of new arrangements of telephones is a very convenient one in which an office inkstand is fitted with a small transmitter and receiver (Fig. 2).

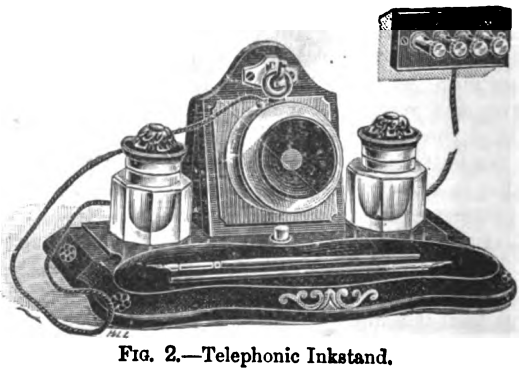

Fig. 2.—Telephonic Inkstand.

A switchboard for use with compound-wound motors is exhibited by this firm (Fig. 3). Four switches are arranged on the board, respectively for excitation, main circuit, resistance, and

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reversing of the series-wound field. The series-winding, which in a compound motor necessarily opposes the field produced by the shunt, in order to produce compounding, is a hindrance to the development of a strong field and powerful torque at starting. In the above arrangement the series-winding is made to contribute to, instead of detracting from, the torque at starting, by utilising the coils reversed. As soon as the motor has attained its speed the coils are reversed again to perform their compounding action. The switches on the board referred to above are provided with locking cams, which effectually prevent the switches being turned in any other but their proper order. Thus the main current cannot be switched on to the motor until the shunt field switch is closed and the motor is fully excited. Similarly the main current cannot be switched on unless the resistance switch is at its highest point.

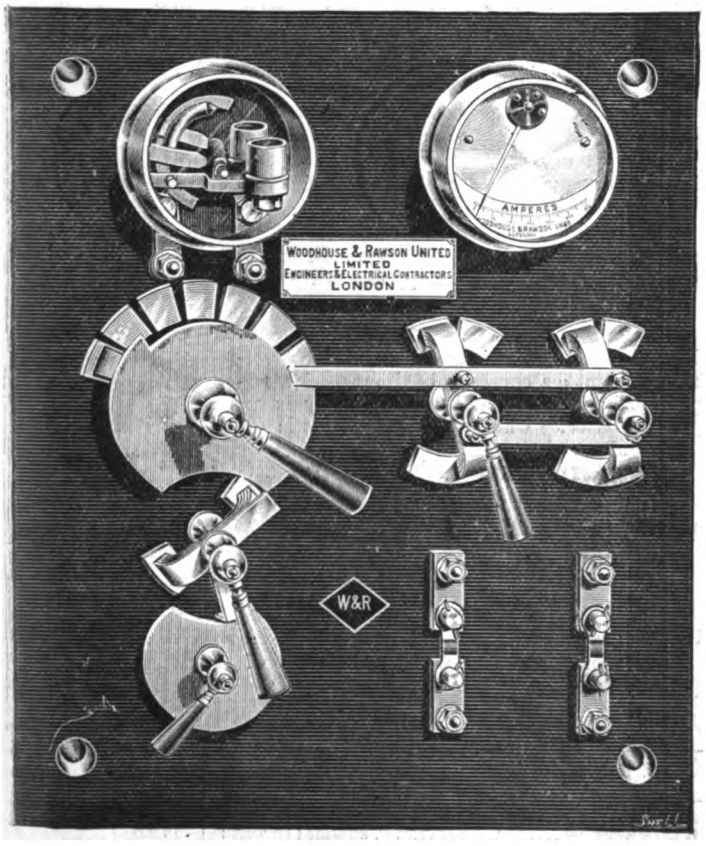

FIG. 3.—Switchboard for Compound-wound Motors.

After the motor is started and the resistance is gradually reduced, it is impossible to take all the resistance out until the switch controlling the series-winding is put back so as to bring the coils into their right direction for compounding. It is by such carefully thought-out arrangements as these that the cost of maintenance may be minimised by enabling the apparatus to be safely controlled by an unskilled attendant.

REVIEWS.

The Universal Office Manual. By OXBARROW AND MONEY-KENT. (Wightman and Co., 31, Victoria-street, S.W.)

This is a work designed to assist those who are not fully acquainted with the routine of counting-house work. The book consists of about 120 large oblong pages, and contains a number of special rulings for counting-house books, with printed examples of many special varieties of book-keeping, and will doubtless be most acceptable to many persons to whom the mysteries of book-keeping form one of the most difficult features in their every-day work. In addition to the rulings referred to a glossary of business terms is given. The book is well got up, and should prove to be of great use.

ON THE LAW OF HYSTERESIS.*

BY CHAS. PROTEUS STEINMETZ.

(*Concluded from page 410.*)

Magnetometer Tests.

The method used in the foregoing has the great advantage that

1. It allows the taking of a greater number of readings, over a wide range of magnetisation, in a short time, by mere simultaneous instrument readings, and thereby reduces the probable error by increasing the number of observations.

2. It allows the use of electro-dynamometers, as the most reliable electric measuring instruments.

3. It deals with larger amounts of energy, counting by watts or even hundreds of watts, whereby a much greater accuracy can be reached than by the ballistic galvanometer.

4. It measures the hysteresis under the influence of an harmonically, and not suddenly varying, M.M.F., that is under the same conditions, where it becomes of importance for practical engineering.

But it has the great disadvantage that it can be used only for testing sheet-iron or other thoroughly-laminated iron, where eddies are either inappreciable or can be calculated. For testing solid iron and steel pieces, this method cannot be used, because of the tremendous amount of eddies which would flow in a solid piece of iron.

To determine the hysteretic loss of energy in steel and cast-iron the Eickemeyer differential magnetometer was used. Complete description of this instrument and its use is to be found in the *Electrical Engineer* of New York, March 25, 1891. An exhaustive series of experiments were made with this instrument on several kinds of iron. The results are briefly summarised in the following tables :—

TABLE V.—*Magnetic Characteristic.*

F in ampere turns per centimetre length of magnetic circuit.
B in lines of magnetic force per square centimetre.

F	B	F	B	F	B
10	750	70	2930	140	3770
20	1510	80	3080	160	3930
30	2000	90	3220	180	4070
40	2320	100	3350	200	4200
50	2560	110	3470	220	4310
60	2760	120	3580	240	4400

TABLE VI.—$H = \eta B^{1.6}$.

H in ergs per cycle and cm.^{3}. B in lines of magnetic force per cm.^{2}. F in ampere turns per cm.

Material.	Hysteretic coefficient. η	Magnetisation at the M.M.F. $F=10$	$=40$	$=90$
Very soft iron wire (Ewing)	·0020	12800	14700	16600
Westinghouse converter, sheet-iron	·0024	14400	17800	20800
Very thin sheet-iron, standard	·0030 *	13100	17100	20700
Thick sheet-iron	·00333†	13100	17500	—
Sheet-iron	·00421‡	—	—	—
Sheet-iron	·00450§	—	—	—
Soft annealed cast-steel	·0080	7800‖	14000	16300
Soft machine steel	·0094	5800	14800	18800
Cast-steel of low susceptibility	·0120	2000	6400	9800
Cast-iron	·0162	1600	6100	10100
Hardened cast-steel	·0250	1200	8000	12900
Magnetic iron ore	·02045	750	2320	3220

* For $n=100$. † $\epsilon = \cdot 746 \times 10^{-6}$. ‡ $\epsilon = \cdot 2083 \times 10^{-6}$. § $\epsilon = \cdot 116 \times 10^{-6}$.
‖ This and the following values of this column are derived as average of rising and decreasing branch of the magnetic characteristic, because at $F=10$ the magnetism is still very unstable.

In Fig. 7 is given a comparison of the hysteretic curves of—

Hardened steel. Annealed steel. Cast-iron. Magnetic iron ore, in the same size.

This figure shows well the three characteristic forms of hysteretic curves.

1. The hardened steel curve, of high coercitive force, has the bend or "knee" on the *negative* side, so that for zero M.M.F. the

* Abstract of a Paper read before the American Institute of Electrica Engineers, New York, January 19, 1892.

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TABLE VII.—$W = \gamma H^{1\cdot6}$

W in watts per cubic inch and 100 complete periods per second. H in lines of magnetic force per square inch.

γ	$H=$	10,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	90,000	100,000	110,000	120,000	150,000
Very soft iron wire (Ewing) ...166×10^{-10}	$W=$	·042	·13	·24	·38	·55	·73	·91	1·16	1·40	1·66	1·94	2·23	3·18
Westinghouse con., sheet-iron..201		·051	·15	·29	·46	·66	·89	1·14	1·41	1·70	2·01	2·34	2·69	3·84
Very thin sheet-iron 249		·063	·19	·36	·58	·82	1·10	1·41	1·74	2·11	2·49	2·90	3·34	4·77
Thick sheet-iron 277		·070	·21	·40	·64	·91	1·22	1·56	1·94	2·34	2·77	3·22	3·71	5·30
Sheet-iron.....350		·089	·27	·50	·81	1·15	1·55	1·98	2·45	2·96	3·50	4·07	4·69	6·69
Sheet-iron.....374		·095	·29	·54	·87	1·23	1·66	2·12	2·62	3·17	3·75	4·36	5·02	7·17
Soft annealed cast-steel 663		·17	·51	·97	1·53	2·19	2·93	3·75	4·64	5·60	6·63	7·73	8·88	12·7
Machine steel, soft 778		·20	·59	1·14	1·80	2·57	3·44	4·40	5·45	6·57	7·78	9·06	10·4	14·9
Cast-steel of low susceptibility..994		·25	·76	1·45	2·30	3·28	4·39	5·62	6·95	8·39	9·94	11·6	13·3	19·0
Cast-iron 1,346		·34	1·02	1·96	3·11	4·44	5·94	7·60	9·41	10·9	13·4	15·7	17·6	25·8
Hardened cast-steel 2,077		·52	1·58	3·03	4·80	6·85	9·18	11·7	14·6	17·5	20·7	24·2	27·8	39·8

$H = 25{,}000$; alternate current transformer, American style (high frequency).

$H = 35{,}000$; alternate current transformer, European style (low frequency).

Only the values smaller than ·25 W, can be of practical use ; in those larger than 10 the iron gets at least red hot if in larger quantities.

"remanent" magnetism is still in the saturation part of the curve—that is, in stable equilibrium ; therefore permanently magnetisable.

2. The soft iron curve, with the bend on the *positive* side, so that for zero M.M.F. the "remanent" magnetism, though still very high, is already below the range of saturation, on the branch of unstable equilibrium. Therefore, the remanent magnetism is very unstable and easily destroyed, the more as the coercitive force is very small.

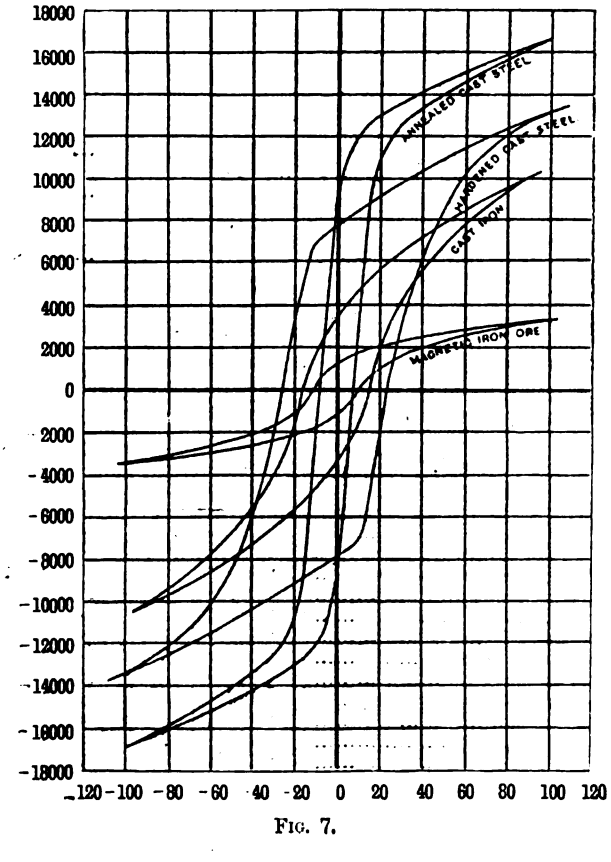

FIG. 7.

3. The cast-iron curve, which has no marked knee at all, but a steady curvature of low remanent magnetisation, but with regard to coercitive force ranging between 1 and 2.

The curve of the magnetic iron ore shows all the characteristics of a cast-iron curve.

Having derived, now, a larger number of values of the hysteretic coefficient η for different kinds of iron and other material, we shall put them together for comparison in Table VI.

For convenience, in Table VII. are given the values W of consumption of energy in watts per cubic inch for 100 complete periods (magnetic cycles) per second, and for the magnetisation of H lines of force per square inch, giving as coefficient of hysteretic resistance the value $\gamma = 8{\cdot}3 \times 10^{-6} \eta$.

In this Table I have given a number of experimental values of the consumption of energy by hysteresis, and believe to have shown that this consumption of energy can fairly well be expressed by the empirical formula,

$$H = \eta \quad ^{x}$$

where the exponent x is equal, or at least very nearly, to 1·6, and the coefficient η a constant of the material, which ranges from ·002 up to ·025 and more, and may possibly have a slight dependence upon the *velocity* wherewith the magnetic cycle is performed, as the second set of alternate-current readings seems to indicate.

In Table VIII., I give the values of the hysteretic resistance η for some iron samples, subjected to a magnetic cycle between $F = +190$ and -190 ampere turns per centimetre, calculated from Hopkinson's tests * by the assumption of the law of hysteresis.

η denotes the coefficient of hysteresis.

B the maximum magnetisation in lines of magnetic force per square centimetre.

R the remanent magnetisation in lines of magnetic force per square centimetre.

TABLE VIII.

Material.	Condition.	η	B	R
Wrought iron	Annealed.....	·00262	18,250	7,250
Soft Bessemer steel	·045 per cent. C. annealed	·00262	18,200	7,860
Soft Whitworth steel ..	·09 ,, ,, ,,	·00257	19,840	7,080
	·32 ,, ,, ,,	·00598	18,740	9,840
	·89 ,, ,, ,,	·00786	16,120	10,740
	·32 ,, ,, oil-hard..	·00954	18,800	11,040
	·89 ,, ,, ,,	·01844	16,120	8,740
Silicon steel	3·44 ,, Si., wrought	·00937	15,150	11,070
	3·44 ,, ,, annealed	·00784	14,700	8,150
	3·44 ,, ,, oil-hard..	·01282	14,700	8,089
Manganese steel	4·73 ,, Mn., wrought	·05963	4,620	220
	8·74 ,, ,, ,,	..	747	..
	12 36 ,, ,, ,,	..	310	..
	4·73 ,, ,, annealed	·04146	10,580	5,850
	8·74 ,, ,, ,,	·08184	1,985	540
	4·73 ,, ,, oil-hard..	·06706	4,770	2,160
	8·74 ,, ,, ,,	..	733	..
Chrome steel...	·62 ,, Cr., wrought	·01179	15,780	9,320
	1·2 ,, ,, ,,	·01851	14,080	7,570
	·62 ,, ,, annealed	·00897	14,850	7,570
	1·2 ,, ,, ,,	·01638	13,230	6,490
	·62 ,, ,, oil-hard..	·03958	13,960	8,600
	1·2 ,, ,, ,,	·04442	12,870	7,890
Tungsten steel	4·65 ,, Wo., wrought	·01516	15,720	10,140
	4·65 ,, ,, annealed	·01435	16,500	11,010
	3 44 ,, ,, oil-hard..	·04776	14,480	8,640
	3·35 ,, ,, very hard	·05778	12,130	6,820
Grey cast iron	3·45 p. c. C. ; 17 p. c. Mn.	·01826	9,150	3,160
White cast iron.....	2·04 ,, C. ; 34 ,, ,,	·01616	9,340	5,550
,, ,, ...	4·5 ,, C. ; 8·0 ,, ,,	..	385	77

These values of the hysteretic resistance vary from ·002 up to ·082, 41 times the first value.

But especially marked is, that η depends much less upon the chemical constitution of the iron sample than upon its physical condition, *annealing decreasing* and *hardening increasing* the hysteresis very considerably.

* From "Kalender fur Electrotechniker," by Uppenborn, Berlin, Germany.

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So far as the chemical constitution is concerned, the purer the iron the lower is its hysteresis, while any kind of foreign matter increases the hysteresis. Especially manganese increases the hysteretic loss enormously, much less wolfram and chromium, least silicon and carbon. Connected with the increase of hysteresis is always a decrease in susceptibility.

To combine the results, what I believe I have proved is that loss of energy in iron caused by reversals of magnetism can be expressed by the analytical formula

$$H = \eta B^{1.6} + \epsilon n B^2$$

where η is the coefficient of hysteresis, ϵ the coefficient of eddy currents, n the frequency of the alternations of magnetism, $\eta B^{1.6}$ the loss of energy by hysteresis proper, or by *molecular friction*, and $\epsilon n B^2$ the loss of energy by eddy currents, per magnetic cycle and per cm.^{3}, proportional to the frequency n.

TABLE IX.

	$B^{1.6}$	Increase per 100	B	$B^{1.6}$	Increase per 100	B	$B^{1.6}$	Increase per 100
500	·0208	42	9.000	2·122	378	17,000	5·870	55
1000	·0631	85	9.500	2·313	389	17,500	6·148	56
1500	·1206	115	10.000	2·511	400	18,000	6·434	57
2000	·1913	142	10.500	2·716	41	18,500	6·722	58
2500	·2732	164	11,000	2·925	42	19,000	7·017	59
3000	·3659	185	11,500	3·141	43	19,500	7·312	59
3500	·4684	205	12.000	3·363	44	20,000	7·613	60
4000	·5800	223	12.500	3·589	45	22,000	8·868	63
4500	·7000	240	13.000	3·821	46	24,000	10·193	66
5000	·8288	258	13.500	4·060	47	26,000	11·59	70
5500	·9662	275	14.000	4·303	48	28,000	13·05	73
6000	1·111	292	14.500	4·580	49	30,000	14·57	76
6500	1·261	308	15,000	4·807	50	35,000	18.65	82
7000	1·420	324	15,500	5·062	51	40,000	23·09	89
7500	1·583	339	16,000	5·429	53	45,000	27·87	96
8000	1·758	353	16,500	5·598	54	50,000	33·00	103
8500	1·936	366						

For convenience, I give in Table IX., the values of the 1·6th power of the numbers, from 500 to 50,000 with the parts proportional, or the increase of $B^{1.6}$ for 100 lines of magnetic force.

PHYSICAL SOCIETY.

At the annual general meeting of this Society on Friday, February 12th, Prof. W. E. Ayrton, F.R.S., President, in the Chair, the report of the Council was read by the President, as were also the obituary notices of Prof. W. Weber, late honorary member, Mr. W. G. Gregory, and Prof. James Crouch Adams.

The following gentlemen were declared duly elected to form the new council :—President : Prof. G. F. Fitzgerald, M.A., F.R.S. Vice Presidents : Prof. A. W. Rücker, M.A., F.R.S. ; Walter Baily, M.A. ; Prof. O. J. Lodge, D.Sc., F.R.S. ; Prof. S. P. Thompson, D.Sc., F.R.S. Secretaries : Prof. J. Perry, D.Sc., F.R.S., 31, Brunswick-square, W.C., and T. H. Blakesley, M.A., M.Inst.C.E., Royal Naval College, Greenwich. Treasurer : Dr. E. Atkinson, Portesbery Hill, Camberley, Surrey. Demonstrator : C. Vernon Boys, F.R.S., Physical Laboratory, South Kensington. Other members of Council : Mr. Shelford Bidwell, M.A., F.R.S. ; Dr. W. E. Sumpner, D.Sc. ; Major-General E. R. Festing, R.E., F.R.S. ; Mr. J. Swinburne ; Prof. J. V. Jones, M.A. ; Rev. F. J. Smith, M.A. ; Prof. W. Stroud, D.Sc. ; Mr. L. Fletcher, M.A., F.R.S. ; Dr. G. M. Whipple, D.Sc. ; Mr. James Wimshurst.

The CHAIRMAN having invited suggestions towards improving the working of the Society,

Prof. S. P. THOMPSON said that as the Society had been established fifteen or sixteen years and had amply justified its existence, the time had now arrived for giving fuller recognition to the privileges of members. He thought they had earned the right to be called "Fellows," and that this ought to be signified by some distinctive title.

Mr. J. SWINBURNE suggested that before Papers were brought before the meetings they should be read by a member of Council. If suitable they should then be printed, and proofs sent to members who applied for them. Mathematical Papers could then be taken as read, and the discussions would be more interesting and to the point. It would also be an advantage if communications on kindred subjects could be taken the same day and discussed together. Papers on purely technical subjects should go to the Technical Societies.

Prof. AYRTON, in reply to Mr. Swinburne, said the members had the matter of Papers in their own hands, for, as pointed out in the Report of the Council, if they would only send in the Papers early enough the secretaries would be glad to group them in the way suggested. Referring to Prof. Thompson's remarks, he said he had often thought it would be an advantage to have another class of members in the shape of "Students," who should hold meetings amongst themselves.

Mr. A. P. TROTTER said the Society was unique in many respects, and he thought it was not desirable to have different grades of membership.

Dr. C. V. BURTON agreed with Mr. Trotter, and said that even if Prof. Thompson's suggestion were adopted, means should be provided that persons could be admitted into the Society without claiming any distinction therefrom.

Prof. S. P. THOMPSON referring to the communications brought before the Society, said it was not necessary that all should possess great novelty. Descriptions of new arrangements of apparatus, of diagrams, and exhibits of modern instruments were of great interest to members.

The CHAIRMAN pointed out that at the early meetings of the Society exhibitions of instruments were frequent, and said the Council would be glad if instrument makers would send apparatus to be shown at any of the meetings.

The meeting was resolved into an ordinary Science meeting, and Prof. S. P. THOMPSON, F.R.S., communicated a "Note on Supplementary Colours," and showed experiments illustrating the subject.

A Paper "On Modes of Representing Electromotive Forces and Currents in Diagrams," by Prof. S. P. Thompson, was postponed.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, February 26th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read : (1) "On Modes of representing Electromotive Forces and Currents in Diagrams." By Prof. S. P. Thompson, F.R.S. (2) "On the Flexure of Long Pillars under their own Weight." By Prof. Maurice FitzGerald, M.B. (3) "On Choking Coils." By Prof. J. Perry, F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read : "The Construction and Efficiency of Locomotive Boilers." By G. H. Sheffield, Stud.Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse : "Optical Projection." By Sir David Salomons, M.A.

SATURDAY, February 27th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture : "Matter at Rest and in Motion." By Lord Rayleigh, F.R.S.

MONDAY, February 29th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. III.—1. "The Uses of Petroleum in Prime Movers." By Prof. William Robinson, Assoc. M.Inst.C.E.

TUESDAY, March 1st.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Papers to be discussed :—(1). "The Bishop Rock Lighthouses." By W. T. Douglass, M.Inst.C.E. (2). "The Illumination by Gas of Tory Island Lighthouse, Co. Donegal." By David C. Salmond, Assoc.M.Inst.C.E. At this Meeting the Monthly Ballot for Members will be taken.

WEDNESDAY, March 2nd.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Spontaneous Ignition of Coal and its Prevention." By Prof. Vivian B. Lewes.

THURSDAY, March 3rd.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting.

CHEMICAL SOCIETY.

8 p.m. Ordinary Meeting.

FRIDAY, March 4th.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Ladies' Night. Concert at St. James's Hall Restaurant.

ROYAL INSTITUTION.

9 p.m. Evening Discourse : "The Surface-Film of Water, and its relation to the Life of Plants and Animals." By Prof. L. C. Miall, F.L.S.

SATURDAY, March 5th.

INSTITUTION OF CIVIL ENGINEERS.

3 p.m. Students' Visit to the Oil-Gas Works of the Great Northern Railway, at Holloway.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture : "Matter at Rest and in Motion." By Lord Rayleigh, F.R.S.

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TELEPHONE REFORM.

About the telephonic service in London it is impossible to have two opinions. No one has yet had the courage to defend it. Excuses and promises are the only replies which grumblings, protests, and, shall we say, imprecations have called forth. If GRAHAM BELL were held responsible for the profanity, and Colonel JACKSON for the loss of temper, that the telephone has caused, their burdens would indeed be serious. Improvement has doubtless been made of late, but the result is only to make communication possible where before it was out of the question, and to improve certain suburban districts where alterations could without serious difficulty be made.

At the crowded meeting at the London Chamber of Commerce on Monday last, although most of the speakers were more or less interested in telephone companies which compete with or intend to compete with the National Telephone Company, little blame was attached to the management, and the dissatisfaction and strongly-expressed complaints showed none of that bitterness which is justly felt at the meetings of the shareholders of ill-managed businesses. The original telephone companies came in for well-deserved reproach for the reckless mismanagement and scamped work which will never be properly punished. When every hard word has been said about the service, plenty more remain for the tariff. It is really only on this point that opinions conflict. It is pleaded that the tariff in provincial towns has been largely reduced; this is of course due to potential competition, and the cry at once is, let us have actual competition in London. Some ill-informed apologist thinks that because London is so vast special difficulties arise in the working of the exchanges; but we have only to look to Berlin or Paris and find 17,000 or 10,000 subscribers, as against the 7,000 of the London district. The 80s. per subscriber which

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is spent on wayleaves is a significant sum, and certainly stands for some consideration received, which is more than can be said for the practically obstructive tax of £2 per subscriber which is exacted by the Post Office. But we will not dwell on excuses and complaints—a fair number of these will be found in our report of the meeting in another column. The real cause of the high tariff has been pointed out again and again, viz., the patching-up of the bungling work of the United Telephone Company, and the extravagant expenditure of paper capital on patents. Few monopolists have been better hated than the old United Company, and now that the patents have expired it is felt that their successors, the National Company, possess nothing but a good business—it would indeed be a misnomer to call it "goodwill," and the problem of to-day is how to get an efficient service at a reasonable cost.

On this main question hardly two speakers on Monday were agreed, this chiefly because most of them had axes to grind. The spread of State socialism so far affected the matter that there was an almost unanimous feeling, entirely unanimous if the voting for the resolution be considered, that "the Government ought to do something;" though this wish has been expressed, we believe, even before the Fabian Society sprang, or (is it more accurate to say) struggled, into existence. There was a distinct difference of opinion as to the exact course which it would be best that the Government should adopt. That a meeting of sixty men should hope to move the Government when it has a Bill of its own before Parliament is significant of the British spirit. By far the most reasonable suggestion was, that the Bills of the Telephone Companies should be allowed to go to Committee in order that public opinion should have a fair hearing. Colonel Jackson has a firm conviction that if he can only get compulsory wayleaves under, over and through public, private and other property, nearly all his troubles will vanish, and the troubles of the public are his troubles, for the grievances of the subscribers to his Company are not to be compared with the complaints of passengers on the South-Eastern Railway. Compulsory powers may be given or taken in Berlin; but they will be neither granted nor tolerated in this country. The New Telephone Company, which seems to mean business, asks for permissive powers only, though it remains to be seen how these will be interpreted. We are not convinced by the argument that general compulsory powers are impossible because electric supply companies only have powers over a district by Provisional Orders under the Electric Lighting Acts. There is no apparent reason, as far as that contention goes, why a similar Act should not be passed for telephones. But there is another and much more serious difficulty. We have never stopped to read the Magna Charta when we have passed it in the British Museum, and do not know if it contains a clause which constitutes every Englishman's house as his castle; but that right over his own property will not be given up until the present order of things gives place to Communism. The Post Office is more frequently thwarted by refusals of wayleave than is generally imagined, but the Post Office itself has never, so far as we are aware, attempted to take compulsory powers over private grounds and houses.

Very different views about the Post Office were held by different speakers on Monday. A good case was made out by those who showed that the Post Office had tried to establish telephone service in several towns, and had been beaten in nearly every case as soon as competition, even with single-wire circuits, began. But in view of the possibility that the whole matter may some day fall into its hands, it is well that the department should make a few experiments. It was confessed that trunk lines could be erected between towns, and maintained more efficiently and economically by the Post Office than by private companies; but there was a strong opinion that the Post Office could not be trusted to carry out the service with promptness, cheapness, and efficiency, that red tape and circumlocution would delay repairs to instruments and subscribers' lines, and that the determined obstruction which has already been offered, and the competition with the telegraph which would probably be felt, would make Post Office administration of very doubtful value. It is improbable that any guarantee could be obtained that the Post Office would not make the telephone a mere source of revenue. The advances of socialism have not been such that no voice was raised in favour of private enterprise; on the contrary, State management of commercial matters was discountenanced. But while the day is happily far distant when the Government baker will leave his rolls in the morning, and the Government milkman his milk cans (unless perhaps a pipe line will be laid from dairy to house), there is a distinct difference between a commercial supply and a public service. A Government department ought to be able to carry on a service, and if a monopoly must exist it is, on the whole, better that it should be in Government hands. As far as the London telephones are concerned, there is only one way out of the monopoly difficulty. At present it is essential to a useful service that every subscriber shall be able to communicate with any other. Where considerable competition exists, as at Newcastle, a large number of subscribers pay two subscriptions—the one to the Post Office, attracted, we understand, by good lines and instruments, and the other to the National Telephone Company because of its connections to other towns. Competition on these terms is ridiculous. We would prefer, then, to see the whole system put in the hands of the Post Office, unless an Act can be passed compelling competing companies to put through their own subscribers to those of other companies, precisely as the running powers of railway companies are arranged, the subscriptions to be settled on the Clearing House principle. Colonel Jackson is not altogether averse to being bought up by the State, but we fancy that if such an arrangement with the New Telephone Company were insisted on, and if his longed-for rights to plant poles in a bee line on any roof that was suitable were refused, he would have even less aversion to such a course than he has at present.

Loud and well-deserved as the complaints against the present service may be, the telephone is indispensable in thousands of offices, and with but one reserve we should like to see every endeavour made to facilitate improvements in it. That reserve is that the telephone companies shall not confine or curb the rights and operations of the rest of the electrical industry. To anyone who has heard of the contention of the telephone companies that they have an established right to use the earth as a return, and of their endeavour to stop electric traction and to divert the mains of, and otherwise harass, electric supply companies, it is very surprising that not a single representative of these threatened interests put in an appearance on Monday last. Where were the members of the Electrical Trades' Section of the Chamber? They had all received notice of the meeting. If they were too busy to attend, being for the most part engaged in manufacture, where were the Associated Statutory Supply Companies? The deputation to the Postmaster-General was nominated, and the Supply Companies have only themselves to blame if they are not represented on it, and though this may be no great matter, they will have reason for regret if the Telephone Companies steal a march on them, and succeed in getting even a portion of the powers which they are asking in their Bills.

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ON A DIFFERENTIAL ELECTROSTATIC METHOD OF MEASURING HIGH ELECTRICAL RESISTANCES.*

BY MAJOR CARDEW.

The following method has been found useful for determining the relative value in insulating quality of small samples of materials, the insulation resistance of short pieces of cable, and other very high resistances. The arrangement is also suitable for continuously indicating the position on any electrical circuit, worked at a high pressure, of the resultant fault or point of zero potential; and for measuring the insulation of the circuit while the pressure is on.

Connections.—The method consists in connecting the quadrants of an ordinary quadrant electrometer to the terminals of a source of fairly high E.M.F., while the aluminium vane or needle is connected to earth. The resistance to be determined is connected to one side of this arrangement, and a variable resistance of the same order of magnitude to the other side, the free ends of each being connected to earth.

The centre of the battery, or other source of E.M.F., is then earthed for a short time, bringing the needle to the zero reading, and, after the removal of this earth connection, the needle will travel to one side or the other, unless the resistance to the passage of electricity from each pole to earth is exactly equal, in which case the needle will remain permanently at zero.

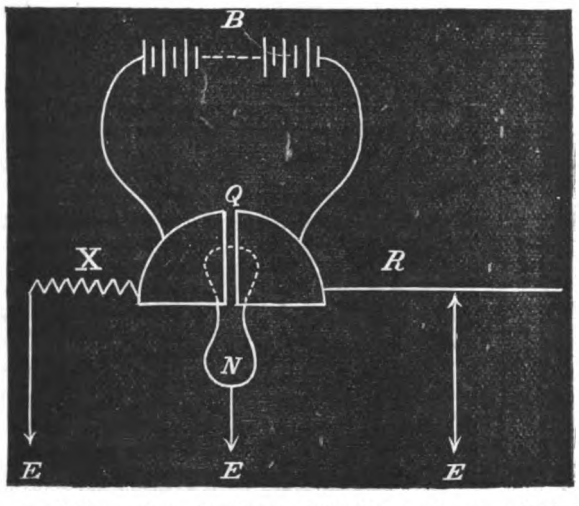

Diagram of Connections for Electrostatic Balance for Very High Resistances. The opposite quadrants of electrometer are not shown.

By observing the motion and varying the comparison resistance accordingly, this balance is soon arrived at, if within the range of variation provided.

The arrangement is shown in the figure, where B is the battery or other source of E.M.F., Q the quadrants, N the needle, X the unknown resistance, and R the variable resistance. The earth contacts are shown by E.

Principle.—The method depends upon the well-known fact that every source of electricity produces equal quantities of what are commonly called the two kinds of electricity in any time, however extended, and at any instant at an equal rate.

I have recently drawn attention to this law as determining the potentials from earth of the two sides of any system of electric supply (*vide* my Paper read on April 23, 1891, at the Institution of Electrical Engineers).

If we conceive, therefore, a perfectly insulated voltaic battery, the potentials of the terminals of this source from earth would be determined by momentarily connecting any one of the metal plates with the earth. Under such conditions, the smallest leakage from either pole to earth through a resistance amounting to many millions of megohms, if unbalanced by any leakage from the other pole, must rapidly reduce the potential of the imperfectly insulated pole to zero. The only limit, therefore, to the possibility of the method is the imperfection of the insulation of the measuring apparatus, and this insulation, with proper precautions, can be easily maintained at a value exceeding 1,000,000 megohms.

Sources of E.M.F.—A very convenient source of E.M.F. for the purpose is the arrangement of small zinc-copper couples in series, moistened by dipping the whole into a pan containing acidulated water, which is in use at the Physical Laboratory at Glasgow University. Four hundred such couples are usually arranged on an ebonite support, and the sensibility with this number is ample.*

A still better source, when alternating currents are available, is a special form of transformer, the secondary coil being suspended in air by a silk cord.

The highest insulation can thus be secured. But when the resistance to be balanced possesses appreciable capacity, the use of an alternating E.M.F. is unsuitable, on account of the masking of the effect of the leakage current proper by the capacity current.

Comparison Resistances.—The variable resistance is, most conveniently, some material of uniform cross section, so that its resistance varies as the length put in circuit. Reels of white silk, cotton, thread, and string are very suitable, and with a few such simple materials, balances can be obtained through a great range of value, although no multiplying or dividing power is possible. Thus, a white embroidery silk has been found to have a resistance of approximately 250,000 megohms per inch; a green thread, partly silk and partly cotton, 10,000 megohms per inch in a dry atmosphere; an ordinary measuring tape, 1,400 megohms per inch, &c., down to a piece of wet tape, which gave 64,000 ohms per inch.

These resistances are, to some extent, affected by the degree of humidity of the air, but, when necessary, they can be rapidly standardised with sufficient accuracy by determining one of the lowest by the usual method; or, as a check, when time allows, a highly insulated condenser can be shunted by a length of silk, and the loss of charge, in a given time, measured.

Unsymmetrical Insulation of Apparatus.—If, from any cause which cannot be discovered or removed, the insulation resistance of the apparatus is unsymmetrical, indicated by the needle taking up a false zero when connection is made between the battery and quadrants, symmetry can be always secured by connecting a length of silk, found by trial, between the more highly insulated pole and earth.

Limits of Accuracy.—The accuracy attainable by this method depends on the sensibility of the electrometer and the potential difference employed.

With an ordinary suspension, however, it has been found that with a battery giving about 350 volts, the difference in reading between that with the centre of the battery earthed and that with the earth connection made at 1 volt from the centre amounted to 12 scale divisions.

This sensibility should, therefore, be ample to secure an accuracy within 1 per cent., which, for resistances of several thousand megohms, is generally sufficient.

Leakage Indicator.—The same principle of balance may be usefully adapted as a leakage indicator for electric supply circuits worked at high pressure. For this purpose a special pattern of electrometer is requisite.

The quadrants are connected, respectively, to the two mains constituting a circuit, and the needle to earth. If the insulation of the entire circuit is good, the potential from earth of the two mains will probably be nearly equal, and the needle will remain at zero; any leakage taking place will disturb the balance to one side or the other. By temporarily switching a small leak first on one side and then on the other, and noting the effect, the absolute value of the insulation may be approximately assessed.

The arrangement is not applicable, however, to a concentric system of mains with alternating currents, or in any case where the capacities are large and seriously unequal.

* Paper read before the Royal Society, January 21, 1892.

* The mahogany legs supplied with this battery should be replaced by grooved ebonite legs, to improve insulation, and it is also of advantage to insert under each leg a piece of sealing-wax. The couples require to be taken out and cleaned occasionally; if allowed to get dirty, the E.M.F. becomes low.

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THE TELEPHONE BILLS.

[COMMUNICATED.]

Bills have been introduced into Parliament during the recent Session by the National Telephone Company and by the New Telephone Company, with the object of obtaining statutory powers giving them additional facilities for conducting the business of telephonic communication. The powers sought by the National Telephone Company's Bill are of vast and far-reaching importance, and do not so far seem to have attracted the attention which they deserve.

After defining that the term "pipe" shall include "any pipe, tube, wire, or other apparatus laid in or under the ground for the supply of gas, water, electricity, or for any other purpose," the Bill proceeds as follows:—

"(1.) They may place and maintain a telephone wire under the public road, and may alter and remove the same.

"(2.) They may place and maintain a telephone wire over any public road, and may place and maintain posts on any public road, and may alter or remove the same.

"(3.) They may for the purposes aforesaid open or break up any public road and alter the position thereunder of any pipe, and do any other necessary act.

"(4.) They may place and maintain a telephone wire over any land or any estuary or branch of the sea, and may attach a telephone wire to any land and may place and maintain posts on any land, and may alter or remove the same."

It provides by Section 4 that the Company, in the exercise of such powers, shall do as little damage "as may be," and pay such compensation as shall be determined in manner provided by the Lands Clauses Acts, in connection with lands taken or injuriously affected. It provides by Section 5 that in altering the position of any pipe the Company "shall cause" as little detriment or inconvenience as circumstances admit, shall give at least 48 hours' notice before commencing works, and shall execute the work under the superintendence of the owners of the pipe. Clause 6 provides that the Company shall not place any telephone wire *under* any public road in London or towns having 30,000 inhabitants or upwards, without the consent of the road authority. Clause 13 provides that the Company shall not carry any telephone wire over any land not being a public road at a less height than 25ft., nor within 6ft. of the roof of any building, except with the consent of the owner or occupier.

The short effect of these powers is:—(1) To give the Telephone Company absolute right to place wires *under or over any private property without any consent*, and to leave the owner to take proceedings to determine the amount of the compensation to be paid to him. (2) To give the Telephone Company the right to place telephone wires OVER *any public road without the consent of anyone*, and under any road in the larger towns with the consent of the local authority; and, in smaller towns, without such consent. (3) To authorise the Telephone Company to *alter the position of any electrical pipes, tubes, wire, or other apparatus without the consent of anyone.*

Heretofore the Telephone Company have mainly carried on their business by means of overhead wires, which have been erected in pursuance of wayleaves obtained from the owners of property, and the business has been carried on as a private enterprise for the benefit of the shareholders.

We do not propose to discuss here the question of the effectiveness or cost of the telephone service; our only object is to call the attention of the electrical industry as a whole to the powers now sought. We are fully aware that so long as the Telephone Company confine their operations to those of a private undertaking, they are perfectly justified in carrying on the business in the manner that they might deem most beneficial to themselves. But when they go to Parliament and ask for compulsory powers to enable them to interfere with the rights of private individuals, it becomes a question of great importance how far such powers shall be granted to them, and to see that the rights of private individuals are not interfered with against their will, except so far as may be absolutely necessary in the interests of the public at large, and subject also to such reasonable regulations as may be desirable.

The deliberations of the Chamber of Commerce resulted in the passing of a resolution that the Government should be urged to bring in a Telephone Bill similar to the Electric Lighting Acts of 1882 and 1888, enabling the Board of Trade or other authority to grant powers to companies seeking statutory authority for carying on the business of telephonic communication. Such a Bill will, no doubt, provide regulations for the protection of the rights of the public and other undertakers, and determine the lines upon which the undertaking may be purchased by the Government or other authority at the end of a specified period or periods.

A few words now upon the proposed powers for altering the position of other electrical works without the consent of the owners. To say nothing of the difference in size and importance between the mains of Electric Light Companies as compared with those of the Telephone Company, it must not be forgotten that electric light mains can only be laid with the consent of the local authority, and subject to such regulations as they shall lay down, and in accordance with plans to be approved by the local authority, or settled by arbitration in case of difference. And it would lead, not only to enormous difficulty, but to great interruption in the supply of light to the public if it did not have the effect of altogether preventing the due conduct by Electric Lighting Companies of their business were these mains to be interfered with at the will of the Telephone Company. The telephone service, notwithstanding its defects, is undoubtedly of considerable value to the community; but, whilst one may have every wish to see the service made perfect, one cannot overlook the fact that it is possible to pay too large a price even for that perfection. The New Telephone Company do not ask for compulsory powers, save with the consent of local authorities or where they are affected by undertakers under provisional orders. They propose to lay down twin wires and to have no earth connections; and the rights asked by them may possibly be granted without detriment to any one, subject to the general questions which have been referred to above.

SOME EXPERIMENTAL INVESTIGATIONS OF ALTERNATE CURRENTS.*

BY ALEXANDER SIEMENS, MEMBER.

Most of the papers read before this Institution on the subject of alternate electric currents, and on apparatus employed for utilising them, have dealt principally with the theoretical side of the question, and undoubtedly have been extremely useful to constructors of alternate-current apparatus. Nevertheless, certain gaps in our knowledge obtruded themselves in practice, and the investigations and experiments which are described in the present communication were undertaken, not so much to verify any particular theory, as to increase our knowledge of useful facts. For convenience of reference, these experiments are not described in chronological order, but they have been grouped together according to the subjects which they are intended to elucidate. Foremost among these is the loss of energy through the heating of iron by induction where alternate electric currents are employed—a subject which engaged the attention of Prof. Ewing and of Dr. J. Hopkinson six years ago, whose researches pointed out the direction in which further experiments should be made. It is well known that this loss is caused by the so-called Foucault currents and by hysteresis. The effect of the former is counteracted by laminating the core of a magnet either by building it up with wires of small diameter or with thin discs, according to the direction of the lines of induction.

A short consideration will show that the heat produced by Foucault currents can be calculated beforehand for a core of known construction and dimensions. Take the case of an iron wire, 1 cm. long, subjected to an induction parallel to its axis of **B** lines per 1 square cm. of its section.

Let r be the radius of the wire, and ρ the radius of the ring, of the width $d\rho$, concentric with the wire. In this ring currents will be produced in the same manner as in the secondary circuit of a transformer.

* Paper read Thursday, 11th February, 1892, before the Institution of Electrical Engineers.

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The maximum induction passing through this ring is $N=\rho^2\pi\,.\,B$. Hence the E.M.F. generated is $E=4\,n\,N\times10^{-8}=4\,n\,\rho^2\,\pi\,B\,10^{-8}$ volts.

If c is the conductivity of the iron employed, the resistance of the ring is $R=1/c\times2\,\pi\,\rho/d\,\rho$; consequently the waste of energy in this ring, expressed in watts, is

$$d\,W=E^2/R=8\,c\,\pi\,n^2\,B^2\,\rho^3\,d\,\rho\,.\,10^{-16}.$$

The total energy wasted in one cm. length of the wire is therefore

$$W=2\,c\,.\,\pi\,.\,n^2\,.\,B^2\,.\,r^4\,.\,10^{-16}\text{ watts.}$$

From this formula a table has been calculated to indicate the waste of energy by Foucault currents in 1 cwt. of iron of the conductivity $c=0{\cdot}102\times10^6$, when an alternate current of the frequency $n=100\sim$ per second was employed.

Induction.	½ mm.	Diameter of Wire. 1 mm.	Diameter of Wire. 2 mm.	3 mm.
B.	watts.	watts.	watts.	watts.
1,000	0·8	3·3	13·3	29·9
2,000	3·3	13·3	53·3	119·9
3,000	7·4	29·9	119·9	269·8
4,000	13·4	53·3	213·3	479·8
5,000	20·8	83·3	333·2	749·7
6,000	29·9	119·9	479·8	1,079·4

In order to determine the total loss of energy caused by the heating of the iron, experiments were made with a specially constructed "cable transformer." This mode of constructing transformers has been foreshadowed by Dr. Werner von Siemens, who proposed in his patent No. 42 of 1886 to surround the primary and secondary circuits of a transformer with iron wire, but his experiments gave no satisfactory results. The subject was recently taken up again, and the present form of these transformers was suggested by Mr. Dieselhorst and Dr. Baur. The principal advantage which is claimed for this form of transformer is that it can be made by machinery, in the same way as a submarine cable is made, the employment of manual labour in putting it together being entirely avoided. A special machine has been designed and erected for completing such transformers in one operation, after the iron core has been prepared on an ordinary rope stranding machine. Besides offering these facilities for manufacture, the peculiar shape of the cable transformer lends itself to a variety of useful applications. For instance, at the Crystal Palace Exhibition one of these transformers connects an alternate-current machine to a high-voltage transformer some distance away, raising the potential of the current at the same time from 80 volts to 2,500 volts.

The transformer used for the experiments has a core of 900 soft iron wires, each 1mm. in diameter by 6 metres long, twisted up in the form of a rope, and surrounded by two windings of copper wire, properly insulated, the one for high voltage and the other for low voltage.

From the fact that the diameter of the transformer is very small compared to its length, it follows that the magnetic field, and consequently the induction in the iron core, is uniformly distributed, with the exception of a slight drop at either end. The mean induction produced by passing an alternate current through the low-voltage circuit was measured by the difference of potential obtained in the high-voltage circuit while no current was passing through the latter.

The temperature of the iron core was ascertained by measuring the increase in the electrical resistance of one of its wires, which had been insulated from the rest by a cotton covering.

By actual comparison it was found that one of the wires near the periphery gave, within the limits of errors of observation, the same results as the central wire, so that the exact position of this "test wire" has no influence on the result; the heating of the cotton insulation can be neglected, as its mass is so very small compared with that of the iron.

Separate tests were made to determine the specific heat of the iron, which was found to be $=0{\cdot}112$, and the temperature coefficient for the electrical resistance of the test wire, which was equal to 0·0054.

The current was kept on for a short time only, as it was desired in the first instance to determine the rate at which energy is converted into heat in such a transformer, and the rise in temperature after keeping the current on for s seconds can be calculated from the formula,

$$t_s=\frac{R_s-R_0}{\cdot0054\,.\,R_0}.$$

R_0 = electrical resistance before starting the current; R_s = electrical resistance after keeping the current on for s seconds.

During the time that the current passes, the test-wire will lose a certain amount of heat by radiation and convection, although it is surrounded by all the other iron wires, which are heated in a similar manner. This loss can, however, easily be allowed for by plotting a "cooling curve" after the passage of the current has been stopped, with times as abscissæ and temperatures as ordinates. In this way the rise of temperature of the iron core per second was observed with an alternate current of 100 $\sim$ per second, varying in strength so as to produce a different induction for ach observation.

Considering that the loss of energy caused by the heating of the iron is proportionate to its mass, to its specific heat, and to its rise of temperature per second, it was possible to plot a curve in which the maximum number of C.G.S. lines per square cm. are the abscissæ, and the losses of energy are represented as ordinates calculated for the mass of 1cwt. of soft iron wires 1mm. in diameter.

It should be added that the abscissæ of curve 2, Diagram I., which embodies the results obtained, have been calculated from the measured volts, instead of from the calculated mean volts, which in sinoidal waves are $=0{\cdot}9$ measured volt. This was done as curve 2 was to be used for designing transformers where the measured volts only are used for calculation. As this curve gives the losses caused by hysteresis and by Foucault currents, while the formula given above enables us to calculate the losses caused by the Foucault currents alone, we can determine the loss by hysteresis alone by a simple subtraction.

All these results, it must be remembered, refer to 1cwt. of soft iron, subdivided into wires of 1mm. diameter, on which an alternate current is acting of a frequency of 100 $\sim$ per second, the type of apparatus used being a cable transformer.

The following table shows the results:—

Induction.	Curve 2.	Losses of energy. Foucault currents.	Hysteresis
B=	watts.	watts.	watts.
1,000	43·2	3 3	39·9
2,000	96·2	13·3	82·9
3,000	158·0	29·9	128·1
4,000	231 2	53 3	177·8
5,000	309·5	83 3	226·2
6,000	390·1	119·9	270·2

The losses caused by hysteresis are independent of the dimensions of the iron; this table enables us, therefore, together with the formula for the losses caused by Foucault currents, to predetermine the rate of the loss of energy in iron wire of any weight or dimensions when acted upon by an alternate current of a frequency equal to 100 $\sim$ per second.

Similar experiments were made with alternate currents of a frequency of 66·6 $\sim$ per second, and of a frequency of 133·3 $\sim$ per second, and the curves embodying the results are also shown on diagram I. It should be observed that the currents of 66·6 and of 100 $\sim$ were obtained from the same alternate-current machine (type W_1), which has a high self-induction in the armature, and of which it has been ascertained experimentally that the waves of its current are sinoidal. The currents of 133 $\sim$ per second were produced by another type of machine (W_{11}) with a low self-induction and a very narrow field.

On diagram II. the losses by hysteresis alone have been shown, derived from the curves of diagram I. by deducting the losses caused by Foucault currents according to calculation. By way of comparison, Professor Ewing's curve of losses caused by static hysteresis has been added. In this table the results obtained with alternate currents of 133·3 $\sim$ per second have been left out of consideration, on account of their being made with a different machine, as just explained.

The next point to be investigated is the change which an alteration of the frequency of the current will involve in the case of a transformer designed for a given voltage in its secondary circuit. If it is borne in mind that this voltage, apart from the constant factors, depends on the product $n\,N$ (n denoting the frequency, and N the maximum number of lines of induction), it follows at once that, in order to produce the same E.M.F. with a lower frequency, the number of lines of induction has to be increased in proportion, and *vice versa*. In other words, if the same E.M.F. is to be produced in the secondary circuit of a given transformer, the product $n\,N$ must be constant. This result can at once be applied to the formula, which gives the losses of energy caused by Foucault currents—

$$W=2\,c\,\pi\,n^2\,B^2\,r^4\,10^{-16};$$

and as $N=r^2\,.\,\pi\,.\,B$, the formula can be expressed—

$$W=\frac{2\,c}{\pi}(n\,N)^2\,10^{-16};$$

or, in other words, these losses are constant for the same trans-

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former, whatever the frequency may be, as long as the E.M.F. of the secondary circuit remains the same.

A comparison of the curves for a frequency of 66·7 and of 100 ∿ per second on Diagram I. shows that the losses of energy for the same induction are practically proportional to the frequencies. The same curves show that this loss increases more rapidly than the number of lines of induction.

weights of the iron and of the copper used in its construction are equal to each other and to 1 cwt.; this may be called the normal transformer. If, now, another transformer, of the same series but with a lower induction, is to produce the same voltage, the section of the iron has to be increased proportionately; for instance, in the case of B = 2,500 it has to be doubled. The weight of the iron employed varies, in fact, inversely as the induction, and their

DIAGRAM I.

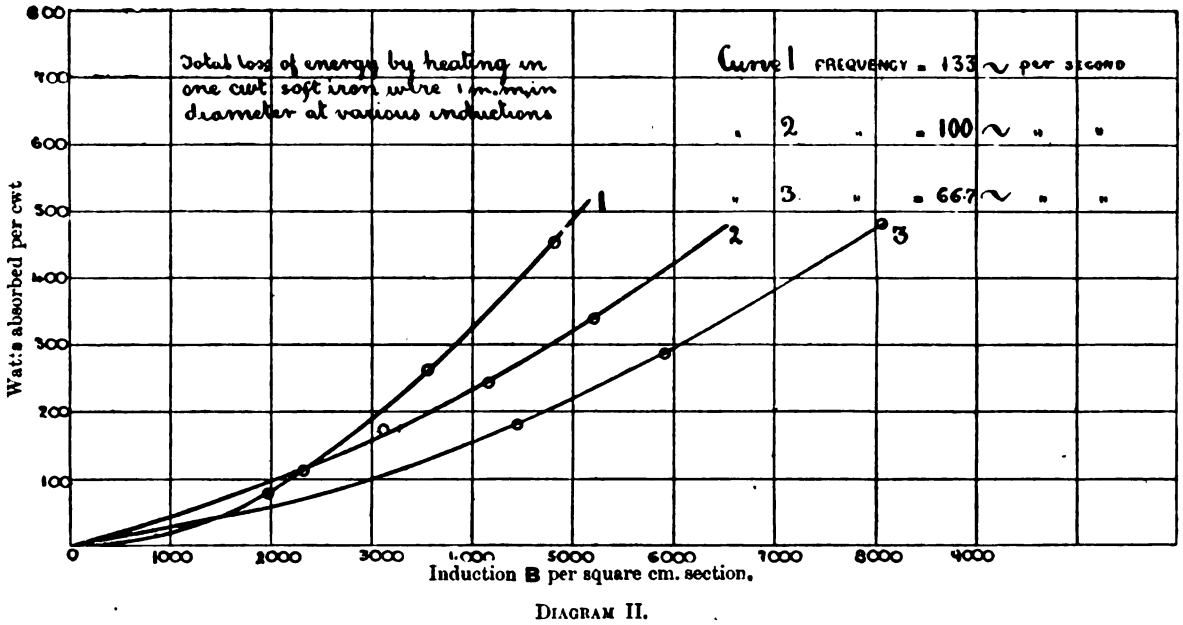
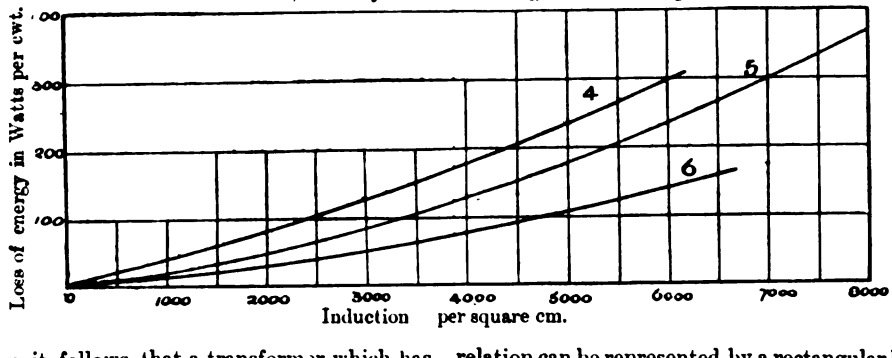

Total loss of energy by heating in one cwt. soft iron wire 1 m.m. in diameter at various inductions
Curve 1 FREQUENCY = 133 ∿ per second
" 2 " = 100 ∿ " "
" 3 " = 66·7 ∿ " "
Watts absorbed per cwt
Induction B per square cm. section.

DIAGRAM II.

Loss by Hysteresis only—Curve 4, frequency = 100 ∿ per second; curve 5, frequency = 66·7 ∿ per second; curve 6, static hysteresis according to Prof. Ewing.



From this consideration it follows that a transformer which has been designed to produce a certain E.M.F. in its secondary circuit with a given frequency cannot produce the same E.M.F. with a lower frequency without over-heating, while it remains cooler when it is worked with a higher frequency. In other words, transformers built for low frequency require much material.

An experiment was made to ascertain the final temperatures of a 50-H.P. transformer worked with different frequencies, and after 10 hours' working the maximum temperature was found to be—For a frequency of 100 ∿ per second, 53°C. in the core, and 46°C. on the outside; for a frequency of 66 ∿ per second, 69°C. in the core, and 57°C. on the outside—a result which appears to bear out the above consideration.

What frequency is most advantageous can, however, not be settled by taking into account nothing but the heating of the transformers: it is quite evident that the construction of suitable generating apparatus plays as important a part; and the problem resolves itself into the commercial one: which combination of apparatus can be constructed most cheaply?

The question, what induction should be settled upon in designing a transformer, is rather a complex one, and it can only be solved by taking into consideration—

1st. The amount of material, iron and copper.

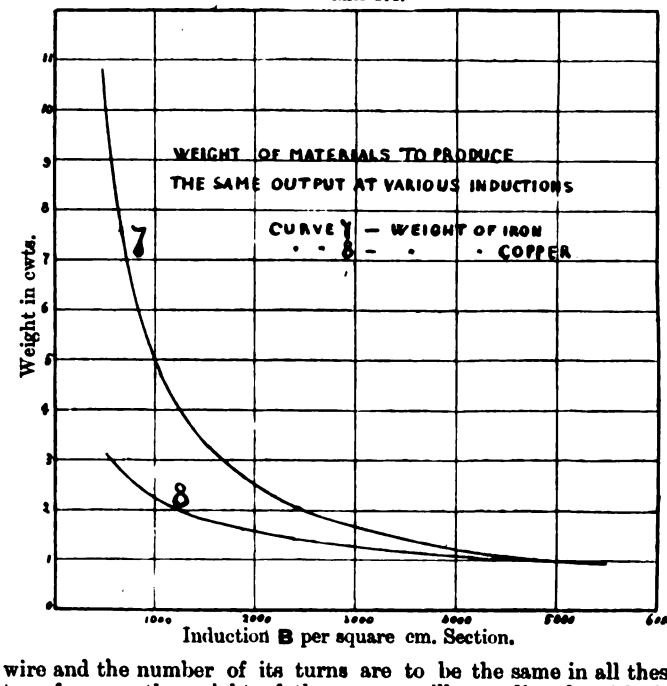
2nd. The drop of potential difference in the secondary circuit from no load to full load.

3rd. The efficiency of the apparatus.

4th. The heating of the apparatus.

In order to facilitate the investigations a series of transformers is compared which all have the same length of iron core, and the same number of turns of copper wire of the same diameter. It is assumed that one of these transformers is designed for an induction B = 5,000, and that its output is such that the relation can be represented by a rectangular hyperbola (Diagram III., curve 7). As we have assumed that the thickness of the copper

DIAGRAM III.


WEIGHT OF MATERIALS TO PRODUCE THE SAME OUTPUT AT VARIOUS INDUCTIONS
CURVE 7 — WEIGHT OF IRON
" 8 — " " COPPER
Weight in cwts.
Induction B per square cm. Section.

wire and the number of its turns are to be the same in all these transformers, the weight of the copper will vary directly with the

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length of wire wound on the iron core, and this can be determined if the relationship between the length of periphery and the section of the iron core is known. In the case of the sections of the cores being circles or squares or rectangles, with the same ratio between their length and width, the length of the periphery varies as the square root of the section. As transformers are generally designed with cores of this kind, it may be accepted that the periphery of the iron core, and, consequently, the weight of copper to be employed, varies as the square root of the section of the iron core.

The weight of copper in the series of transformers under contemplation can therefore be represented by a curve (Diagram III., No. 8) the ordinates of which are the square root of the ordinates of the curve giving the weight of iron for the corresponding inductions. From these two curves it appears that the weight of the iron increases very rapidly with decreasing induction, while the weight of copper increases at a slower rate.

As materials are important items in the cost of a transformer, the consideration of the first point shows the desirability of employing a strong induction. A similar conclusion will be drawn from the investigation of the relation between the induction and the drop of difference of potential in the secondary circuit of the series of transformers. As they are all supposed to give the same current, the drop from no load to full load will be in proportion to the resistance of the circuit. This resistance is in proportion to the weight of copper employed, as all the transformers are assumed to be wound with wire of the same diameter. The curve (8) giving the weight of copper at different inductions will therefore also indicate, in comparison with the normal transformer, the variation in the drop of potential between no load and full load under the same circumstances.

(To be continued.)

THE LONDON TELEPHONE SERVICE.

A special general meeting of the London Chamber of Commerce was held on Monday in the Council Room, Botolph House, Eastcheap, Sir Albert K. Rollit, M.P., presiding, "to consider the general position of the commercial community in regard to the Telephone Service of London and the Telephone Bills now before Parliament." There was a large attendance.

The CHAIRMAN, after stating the object for which the meeting had been convened, said he thought he need not say, as Chairman of the Council, that the feeling of the Council on the subject which they had met to consider was probably the feeling of every member of the Chamber, namely, that the question was not only one of the most important that could be brought before the Chamber, but that its importance was increasing day by day. Owing to the competition which our merchants and others had to meet in the markets of the world, despatch was daily becoming more and more an element of business, and they felt that the saving of time was the only means of making a profit. For these reasons it became of very great importance to consider whether their methods of communication, of transport, and the like, were in the most efficient condition ; and that the public mind was directed very much to these questions was shown by the interest which was taken in the Railway Bills when they were before Parliament, and by the interest which was now beginning to be shown in the Telephone Bills which Parliament had to consider this Session. The Chamber had long taken an interest in these matters. It had appointed one, if not more, committees for considering it, and as some differences of opinion had existed on these committees, it had been thought desirable that the whole of the members should be called together to consider the subject. He thought that perhaps one of the first questions they would have to deal with would be whether, considering the importance of communications as an element of commerce, the fullest and best development had been given to the telephone system in this country under existing conditions, and whether other nations were enjoying greater advantages and greater cheapness from the system than we were. For his own part, although he intended to forbear from expressing any strong opinion, and although his mind, as Chairman, would be kept open for what he might hear, he could not help thinking, from the experience he had had of various telephone systems in foreign capitals, that there was greater development of the system there than there was in this country, that it was cheaper, and, on the whole, more effective, he thought. He could not also conceal from himself the fact that in America the long trunk lines were more generally used than in our country, although here we were in nearly the same position as they were across the Atlantic as regarded the circumstances surrounding the use of trunk lines. On the opening of the telephone system between Paris and Marseilles, no communication could have been easier and better. If it were the fact that they were not quite as much in advance as other countries in regard to the telephone system, they must seriously bethink themselves, for if there was one cause of our present commercial position it was because, in relation to steam and such matters, we had been in advance of all other nations ; and everyone must feel, viewing the importance of the telephone, that we ought to be, at any rate, equal in this country to other nations in this application of electricity. Then came the question as to whether the cost of the telephone in this country was as cheap as it might be, having regard to the experience of other nations. As far as his experience went, he certainly ventured to think that there was room for a reduction in the cost here. The most important question of all, probably, was whether the system in this country was as effective as it might be. He had for many years past taken a scientific interest in electrical questions, telegraphic and telephonic. He possessed the second pair of telephones, apart from any microphones, which were brought to this country, and which were given to him by his friend Prof. Graham Bell. What had struck him had been that the difficulty in regard to telephony had been the cardinal one of induction. As far as he was able to judge, he did not think that this difficulty would be overcome until there was a more general use of a second or return wire. He believed this to be a necessary element of efficiency in the telephone. It might, and probably would, add to the cost, but still, the cost of material was being greatly reduced, and efficiency, after all, was the great consideration. Then there was the element of the mode in which the service was conducted—he meant through its staff—not the superior departments, but those who administered the wires and messages, and on this point his experience was that the service was bad. He was, however, bound in fairness to add that this had been altered and considerably improved. He did not know whether there might not be further improvement. With reference to the Bills in Parliament, as they were aware, whenever a complaint had been made the allegation had been that owing to the absence of powers the telephone companies had been unable to give proper efficiency. In connection with this point they would have to consider, whether, before powers were given to the companies, the assurances they gave were satisfactory that they would consider the public interest first, or, at any rate, equally with the dividend to their shareholders. They had the general principle to bear in mind whether it was desirable that compulsory powers should be given to any private trading company, and, lastly, they had to fall back on the question whether this was not a matter which ought to be conducted by a State department. For his own part, speaking generally, he must say that one's experience of similar things in the past—not of the same undertakings—had led one to the conclusion that wherever the Government could be trusted to provide public facilities better and cheaper than individuals could supply them themselves, there was a manifest advantage in this public supply. There was a manifest disadvantage in the growth of vested interests (as in the case of the water supply), which ultimately had to be bought out at a very serious cost to the community ; and if one could really believe that the telephone, like the telegraph system, could be conducted in a manner thoroughly efficient, and if they could be satisfied that it would not be the case, as in the Post Office, that too much of the receipts were devoted to revenue purposes instead of being applied to the increase of commercial facilities, which was all-important, then he thought there would be a strong inducement to believe that the State ought to do its duty in this matter, and that the efficient performance of this duty should be insisted upon and required from Parliament by the community. He thought there was a further consideration which ought not to be lost sight of, namely, that this matter was important, not only directly, but also indirectly. Directly, it was important as an element of commerce in cheapening the cost of production, but indirectly, electrical engineering was a branch of science to the scope of which in these days there appeared to be no limit. Many industries were dependent on it. A branch of industry which employed almost countless numbers of people was one which should be managed in the most progressive way in this country. He mentioned this last reason as an additional one to those which he had already indicated. They might say that this great branch of trade—electricity—underlied all other trades. It was, therefore of vital importance to the community that every possible advance should be made, that the public mind should be kept educated on all points, and that the public should have the advantage given to it of all progressive improvements. To a great extent this would be done through the general and technical education which so many were now advocating ; but it must be borne in mind that practical education in the shops was of the first importance. This country had placed itself at the very head of mechanical arts, and it ought to be in the forefront in this matter. They must insist that the best and the most recent facilities should be given to the public in supplying their commercial wants, this being of vital importance to the country ; and that was the spirit in which he hoped this important subject would be discussed that day.

Mr. F. W. REYNOLDS said that as the Chairman had appealed to some member of the Chamber in connection with the moving of a resolution, it would, perhaps facilitate matters if he himself did so. At the present moment, as they were all aware, they were severely handicapped in nearly all the markets of the world, and they had only just had to submit to further imposts on the part of the French Government. The American markets were closed to them, or nearly so, and therefore it was a matter of the greatest importance to them to get quick answers to their enquiries. He had had several cases of foreign merchants being in this country and wanting certain orders executed, and it had not been a question of price with them, so much as the rapidity with which the work could be done. He was not afraid, nor were British manufacturers and merchants, of any competition, but they certainly looked to their getting every facility given to them so that they might not be more handicapped than they were already. He thought they should approach the Government, and ask them to give such facilities, or do the work themselves, as would ensure the best means of communication being provided. He had a private wire, and he was bound to say that it worked pretty well, and when it got out of order the telephone employes came and put it right. He heard, however, complaints from other people, and in his own case he found it was difficult to get on at the exchanges. He proposed the following resolution :—

"That in view of the importance of the telephone industry, and the fact that two separate Companies have Bills before Parliament, this Chamber should appoint a deputation to apply for an interview with the Postmaster-General and express the views of the Chamber as to the extreme importance of Her Majesty's Government bringing a Bill before Parliament in order to

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dealt with the question of providing means for giving perfect facilities for the development of this enterprise, not only in the Metropolis, but also with regard to inter-town service all over the country."

Mr. J. MARTIN seconded the motion.

Mr. JACKSON enquired the scope of the Bills before Parliament of the two companies.

The CHAIRMAN read the marginal notes of the National Company's Bill and subsequently clauses 36 and 37 of the Bill of the New Telephone Company. He afterwards observed that the powers in the latter Company's Bill appeared to be somewhat more permissive than contractual, as in the case of the National Company's Bill. It was, however, open to those connected with the companies to construe their own Bills.

Mr. J. CHAMBERS said he failed to see the object of applying to the Postmaster-General. The Telephone Committee with which he (the speaker) had been connected for some time had heard both sides of the question, and had had representatives of both companies present at their conferences. He might be thought presumptious in crossing swords with the Chairman, but he would move, as an amendment to the resolution, the resolution which the Telephone Committee proposed, and which was to be put before the Council. It was as follows:—

"That we are of opinion that an efficient telephone service cannot be given to the Metropolis unless statutory powers are conferred on the companies, and the Council of the Chamber are requested to take the necessary steps to give effect to this recommendation."

He failed to see that there could be any monopoly in this matter. They had two large companies, who were urging their claims before the public, and he thought that the public were better served by these companies than they would be by the Post Office. When the National Company went to Birmingham, the Post Office telephone lost—he did not know how many exactly, but a considerable number of their subscribers, who joined the National Company. There had been complaints, but how had they arisen? It was because there were no statutory powers, and sometimes, where it was a case of going only three miles, the Company had to go six miles in order to get at the point they desired to reach. If these companies were ready to serve them, and could get the necessary statutory powers, so that they could efficiently carry out the telephone service in the metropolis, they ought, as commercial men, to strive to secure for them those powers by all the influence they possessed. He did not see where the Post Office came in; and he did not like concentrating everything. He would rather depend on competition, and, of course, the public would go to the company which served them best. He did not like approaching the Postmaster-General, but although he was proposing an amendment, he believed he was quite in accord with the mover of the resolution.

Mr. FAITHFULL BEGG seconded the amendment, observing that everything which had fallen from the previous speaker was in agreement with his own ideas of the question before the meeting. The subject of the development of the telephone resolved itself into the question referred to by the Chairman in his opening remarks—namely, was it to be done by the Post Office or by private enterprise? He quite believed that the time would come when it would be necessary that the Post Office should control the telephone in this country, but if they were to judge by the past, they had no guarantee whatever that the work would be undertaken in any reasonable period if it were left to a public department. The evidence of that was in the fact that when this enterprise began to be opened up, the Post Office intimated publicly to the country that it was willing to undertake the duty, and to establish telephonic exchanges wherever they were called upon to do so; but notwithstanding that, the Post Office was left to-day without any telephone exchange of any importance.—(A voice: "Newcastle.")—He excepted Newcastle, but he did not admit that Newcastle was a telephone exchange of any importance. He maintained that the Post Office was left without any telephone exchange of any importance, and had been beaten by private enterprise out of several towns where it had established some sort of footing. He believed that this was through the genius of the department not being able to deal with this question as it could be dealt with by private enterprise. As to the metropolis, it was well known that the difficulties were such as did not exist in any part of the civilised globe—they were enormous. The number of subscribers to be put into communication was very large, and it was necessary in London, if it was necessary anywhere, that there should be statutory powers. He did not urge that anything exceptional should be granted. The powers to which he had referred had been granted to other companies. They had granted to the Electric Light Companies the power of taking up the streets, and a nice mess they were making of them; but perhaps the result would justify this. They were now beginning to admit that the telephone was of some importance, and why should it not have the same facilities? This was all, he believed, that the mover of the resolution proposed. The Postmaster-General was an interested party. He had telephones of his own. He did not know what good they would get by going to any department. If they appealed at all let them appeal to the Government, and ask that the industry might be given the reasonable powers which were now advocated for its development.

The DUKE of MARLBOROUGH (New Telephone Company) stated that the subject was a very intricate one, and it was of enormous importance to the community at large. He would take the point raised in the second resolution before the Chamber, which Mr. Begg had particularly alluded to—that was, the question of the Postmaster-General in this matter. Let them consider for a moment what the telephone was. In a country the size of England they ought to be able to talk from one end of the country to the other easily. If they had a good system anyone ought to be able to talk with facility from that room to some one in Glasgow. By going to the Post Office they could talk with the greatest facility between London and Paris. It had been said that private enterprise ought to be developed, and that statutory powers ought to be given to the Companies by the Postmaster-General. This was a perfectly open ground for discussion, but he wanted to put before them this consideration. They were not only a Chamber of Commerce, but also members of the Empire from the point of view that they were all taxpayers. They had bought the telegraph at a very great cost, and they were losing money by it. Supposing the telephone developed in the hands of the present two Companies—or more—what would be the effect? The moment they had a perfect trunk system all over England the telegraph would be cut out, and the Government knew this. If the Government had bought up the gasworks they would not have had Bills passed sanctioning the electric light. As to whether they ought to approach the Postmaster-General, he submitted to the Council that the inter-town communications of this country should be in the hands of the Government. There was no Bill they could pass for any Company that would give sufficient powers to the Company to lay this system as the work should be done. The Government could lay systems as much as they liked under their Telegraph Bills; they could lay them economically and cheaply, and could give facilities which a private company could not give—he was speaking about inter-town communications. Their interest as the public could not be served, he maintained, unless the Government took up the inter-town part of the work. They would not get it good or cheap unless it were done by the Government; and they were bound as taxpayers to protect what they had bought—the telegraph. With respect to the Bills before Parliament, there was no doubt that the Post Office had behaved in a most obstructive manner in dealing with this question, and he sympathised very much with the United and the National Companies in not being able to get anything from the Government—in fact, those companies had met with perpetual opposition. He knew that the Postmaster-General was going to bring in a Bill of his own for the purpose of dealing with the telephone and for conducting it on the underground principle. He knew also that both the private Bills were to be opposed by the Postmaster-General. He thought it very unfortunate that the Government should oppose these Bills at the earliest stages. He considered that they ought to be allowed to pass their second reading and get into committee, so that people might come and give evidence for and against them. The public would then be able to judge of what should be done, and the matter would have light thrown on it. He thought it unfair that the Bills should be thrown out in their early stages, but no private Bill before Parliament had a chance if the Government were opposed to it. It was really absolutely necessary that the Chamber of Commerce should take some active line and represent its views to the Government. Otherwise the companies themselves were perfectly powerless to use any influence of their own to get their Bills carried. He thought that the first resolution was an important one. As to whether the Government could do the work of distribution, abroad the telephone was a monopoly in the hands of the Government, and according to the bureaucratic notions prevailing there, the plan suited foreigners. It would not, however, suit Englishmen. They did not want, when a wire was broken, to have to go through some circumlocution office, as abroad, to get anything done. The Government should be like a farmer who kept a lot of cows and sent his milk to London, employing others to deliver the milk. It would be found that the Companies would do the distribution part of the work better than the Government, but undoubtedly the Government would do the inter-trunk work better than a private company. He thought that this was one view of the situation he would like to put before the meeting. With regard to the question of compulsory powers, Parliament would never give statutory or compulsory powers to a private company. There had been several instances where this had been done, and the result had not been satisfactory. The Electric Lighting Companies were different. Provisional Orders were given to different areas, but they were all given under a general Act. They could not pass a general Act for dealing with the telephone. As a matter of fact, Parliament would never grant the principle which the National Company was applying for. They really, therefore, need not consider this question. It was really of no use bringing before Parliament the resolution which had been passed by the Telephone Committee of the Chamber of Commerce, as they would not adopt it and give to a private company the powers asked for. As regarded the question of the cost of the telephone, there was no doubt that the price paid by subscribers of £20 was too much. He did not wish to make any rash statement, but he maintainad that £12 was a proper price for the use of the telephone on the twin-wire system.—(A voice: "£8.")—They ought to be able for their £12 to speak all over London and the Provinces, paying an extra cost to the Government for the latter privilege. An efficient system by which one could hear plainly was of the greatest importance, for unless one could hear, the telephone was a most maddening instrument (laughter). If he were given the power of putting a few tubes under the pavement he would give them a telephone system immediately communicable, and with practically no wires overhead. It was perfectly possible to give a system by which they could get round to five or six people in a few minutes. An eminent patent lawyer, who was thoroughly up in all electrical science, said to him the other day, "Bad as the system is—and nothing could be more execrable—it is worth £1,200 a year to me in my professional business in what it saves." That was the case, and if they could all have in their offices and homes an efficient telephone they would save largely by it in money, time, and the journeys which at present they had to take, to say nothing of the letters which they had to write. He regarded the Bills before Parliament as attempts to bring the backers before public notice, but he urged them to agree to the first resolution as a very important one. With all deference to the gentleman who proposed the amendment, it was of no use going for a *non-possumus*.

Mr. CHAMBERS pointed out that his amendment did not specify that any special powers should be given.

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The DUKE of MARLBOROUGH, continuing, repeated that he did not believe that Parliament would give the statutory powers demanded, either to one or to a dozen companies. On the other hand, it was most valuable that the Chamber should extract from the Government some expression of opinion. They were all very much in the dark, and the only means of finding out what was going to be done was for a Chamber such as theirs to approach the Government, and say to them, in so many words—"We want the development of this enterprise; we want to know whether Parliament is going to give statutory powers to a private company, or if Parliament does not approve of that, whether it will grant such facilities under a general enabling Act, which will allow this important industry to grow."

Colonel R. R. JACKSON (National Telephone Company) said he had listened with great interest to the lucid and compact form in which the Chairman had put before the meeting the questions that it would be called upon to discuss, and he trusted that he would be permitted to deal with a few of them. First of all, he desired to allude to the resolution and the amendment which were before the meeting. For his own part he was utterly indifferent whether the motion or the amendment was carried, because the purpose of both was practically the same—that was, to secure statutory powers under which the companies would be enabled to do their work by the instrumentality of a general Act. The National Company, although they did 83 per cent. of the telephone business of the country, and its sub-companies did 10 per cent. more, did not ask for special powers on behalf of itself. His belief was that such statutory powers as one company might possess ought to be accorded to all, and he thought that the resolution would lead to that conclusion. He thought also that the amendment would lead to the same conclusion, but he considered that the amendment put the matter much more pithily, because it asked simply that some general Act should be passed by Parliament, and that the resolution which had been come to by the Telephone Committee of the London Chamber of Commerce should be accepted by that meeting, and that it should be presented to the Government as indicating the view of the Chamber. He did not believe that a resolution of this kind, put before the Government, which had been passed by a body of men so influential as the merchants of the City of London, could meet with other than respectful attention. The Chairman had referred to the cost of the telephone, and so had the Duke of Marlborough, but neither gentleman was aware that, although the telephone was given to the public much cheaper in some countries than it was in this, it could be worked for much less in other countries than here. Last autumn he was in Germany, and he saw the telephone systems in Dresden and Berlin. Owing to the kind assistance of the British Ambassador, he was permitted to go through the Berlin Exchange system, and he had every information given to him in connection with it. There they had 17,000 subscribers, while in London there were only half this number; but why, could it be offered cheaper there than here? It was in the hands of the Government, and the Government had no wayleave difficulties. The Government planted five exchanges in such parts of Berlin as it thought would be the best, each capable of giving accommodation to 6,000 subscribers. It had about 3,500 subscribers on each, and the wires were run almost as the crow flies from exchange to exchange, and also from the exchanges to the subscriber's office or residence. There was no royalty to pay of 10 per cent., there were no wayleave charges, and where a mile of wire would do only a mile was run. He hardly ventured to tell them what they were paying in London for wayleaves, but it was over 30s. per subscriber; they paid to the Government £2 for royalty; and they often had to run a mile and a half or two miles of wire where one would do. They completed a route, and were then ordered to remove their standards from the top of a building, and, at great cost, they had to take a circuitous route to obtain complete connection. When Sir Albert Rollit and others suggested that there should be a reduction of the cost, he wished to tell them that this was consistent with the desire and principle of the National Telephone Company—that where possible the cost should be reduced. There was a very large reduction all through the Provinces the year before last, and that reduction had had results which encouraged their Company to prefer lower to a higher charge; but what was their experience in London? If they lowered the tariff now in the metropolis, and thus allured to their system a large number of people wanting to have telephonic facilities, they could not connect them up, and until some such resolution as that which had been proposed was passed and given effect to by Parliament, it would be a doubtful policy for the Company to lower its tariff in London, for it would cause disappointment all round. Let them have statutory powers enabling them to do their work as it ought to be done, and then the question of reducing the tariff could be dealt with in earnest. Something was also said about the inadequacy of the service given in London (hear, hear). That "hear, hear" corresponded with his own experience. He entirely concurred with the sentiment. When the National Company took over the system of the United Company, it was found that a general reconstruction was necessary. His Grace had said that the National Company had two exchanges; but instead of two they had 22, and their first effort was to connect these 22 exchanges with such a number of wires as would enable the subscribers on one exchange to talk with rapidity to the subscribers on another. As the distance between them was very great it resulted, as the Duke of Marlborough said a short time ago, in their converting all the connecting wires between the exchanges into metallic circuits. Sir Albert Rollit had very candidly acknowledged that the service had recently been improved. He desired to tell them what happened in the middle of January. After struggling for more than two years to get a sufficient number of wires erected between exchange and exchange, and to convert them into metallic circuits, they succeeded in the middle of January in running nearly an adequate number of these wires to a new switchboard especially constructed for the purpose at Cannon-street, the result being that the service had greatly improved. The Duke of Marlborough was quite mistaken when he thought that these efforts of theirs were all that the National Company intended to do. As regarded an area so large as that of London, with wires so long as many of them were, with an utter incapacity to carry the wires needed overhead—with, therefore, the necessity to run an enormous number of wires underground—they recognised that metallic circuits were indispensable for a perfect system; and, recognising that, nearly two years ago they applied to the Commissioners of Sewers to permit them to put pipes under ground. This would have enabled them to give the City, which contained two-thirds of their metropolitan subscribers, the advantage of a metallic circuit, and they further sought to concentrate the six City exchanges into one. Had the Commissioners of Sewers given them the power asked for, they would now have been a long way towards the development of the metallic loop system in the City; and as soon as they obtained the power which they sought they would take this work in hand. They were also looping or converting into metallic circuits the subscribers' wires in the suburbs. They had done Croydon and Sydenham, and they were taking the others in turn, as the men could get to work. They wished to do the same for Kensington, but they could not obtain the wayleaves. The public was under a grave misapprehension when it thought that the Company did not wish to give the benefit of the metallic circuit to London. The reason they had not given it was because they could not give it; but they did the best they could. A great deal had been said about the twin-wire and the single-wire system as a general factor in efficiency. He wished to point out that throughout Germany—even in Berlin, where, as he had said, they had 17,000 subscribers—they had the single-wire system entirely. In Austria they had the single-wire system everywhere except in Vienna, and the reason they had the double wire in that city was that the authorities insisted on the wires being taken underground. In France they had the single-wire system everywhere but in Paris, and there the construction of the sewers—the peculiar character of the sewers—necessitated the adoption of an underground, and therefore necessarily a metallic circuit service. In this country everywhere but in the Post Office exchanges, and in one exchange at Manchester, the single-wire system prevailed. They had been told that wherever a single-wire system and a metallic circuit system came into contact, the single-wire system must go to the wall. The Duke of Marlborough had touched upon that subject, and he would, therefore, tell them what had happened in Leicester. The Post Office had an exchange there of several years' standing, with 133 subscribers. In January, 1890, the National Company opened an exchange there; and while the Post Office had now 100 subscribers, the National Company had 275. In Hull they were invited by all the public bodies to open an exchange. They did so; and although the Post Office had been nursing its system for ten years, the National had now more subscribers. The single wire system was adapted to places where they could have one exchange, where the wires were not of great length, and where they had not to go underground. He thanked Mr. Chambers for his resolution, which was in harmony with what had been done by the telephone committee of the Chamber; and the gentlemen present for the patience with which they had listened to the statement made by himself; but before sitting down he felt bound to deal with one subject which had been mentioned by the Duke of Marlborough. His Grace had referred to trunk wires, which he said he thought ought to be in the hands of the Government. Now, the National Company had 30,000 miles of trunk wire; and various towns in the Provinces, in Lancashire, in the Midland district, in West Cumberland, and all through Scotland, were connected with each other. Ten million messages a year passed through those wires, and cost less than a penny each. Therefore, the National Company's trunk system, connecting town and town, was of very great importance to the community, and he thought that those who had tried it would say it was efficient. When the Duke of Marlborough said that it ought to be in the hands of the Government, he (the speaker), as connected with the National Company, said that it was of immense importance to them in enabling them to meet the competition which every man engaged in any commercial pursuit had a right to expect. It would be a very long time before any rival could give Manchester the power of talking with Darlington, Sunderland, Sheffield, Birmingham, and London; and the National Company, owing to their bold enterprise in this respect, possessed an advantage which they did not think should be taken from them by the transfer of their trunk system to the Government. If the Government took the trunk system his Company said, let them take the whole.

Mr. PROVAND, M.P., said it was not to be assumed, from what Col. Jackson had said—that the National Company had always succeeded against the Post Office because they used single wires, or that when the double wire and the single wire systems came into competition it was certain that the latter would win.

Colonel JACKSON, interposing, said he had not stated that they had beaten the Post Office because their wires were single.

Mr. PROVAND said that they opened their exchange—the Mutual Company in Manchester—last February, when they had only 100 subscribers, whereas they now had nearly 1,000, and the National Company had about 1,600. The Mutual Company had obtained for their double wire exchange about two-thirds as many subscribers in 12 months as the National Company had obtained in 10 years. Of course their rates were very different. When they began, the National Company's rates in Lancashire were £20, the same as in London. The charge of the Mutual Company was £5 to shareholders in their Company and £6 to non-shareholders. The Company was not entirely mutual, but it was strongly so, for in Manchester they had about 630 shareholders and from 1,300 to 1,400 subscribers. These were not all put on yet, but about 930 were on, and they were putting them on as fast as they could. He wished to correct an impression about the double as against the single wire. No one Man-

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chester who spoke through the Mutual Exchange and who spoke through the National Company's would hesitate to say which was preferable. He was convinced that no Company would be able to give an adequate service to London until they made a double wire service all over the metropolis.

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Mr. Sheriff FOSTER stated that his only interest in the discussion was as a subscriber to the telephone system. He had been glad to gather from what the Duke of Marlborough had said that there were certain persons who were prepared to give an efficient system in London at much less cost. One of the evils, he thought, from which they were suffering in London was that practically there was a total absence of competition, for the different interests had been fused.

Mr. SYDNEY MORSE said that it was evident that both Companies desired statutory powers. As a member of the public he also desired to see statutory powers granted, as then the large claims of the National Telephone Company would no doubt be curtailed. As one largely interested in electric light he thought it should be remembered, as indeed the Chairman had said, that the telephone was not the only or even the most important electrical industry. The fact that the National Company were asking powers to place their wires both over and under any road or land, and to alter the position of any electrical wires or pipes without the consent of the owners, seemed to him to have been overlooked and to require most careful attention and consideration, considering that the National Company in effect claimed an exclusive right to "earth." He also endorsed the view of the Duke of Marlborough that the Government should permit the Bills of the two telephone Companies to go into Committee, that the whole matter might be thoroughly sifted. He urged an amalgamation of the resolution and the amendment before the meeting.

The CHAIRMAN said he had been going to suggest that there was no practical difference between the resolution and the amendment, and he had ventured to make one or two alterations in the resolution which had met with acceptance by the mover. He suggested that the resolution to be put to the meeting should be as follows :—

"That in view of the importance of the telephone industry and the fact that two separate companies have Bills before Parliament, this Chamber should appoint a deputation to apply for an interview with the Postmaster-General, and express the view of the Chamber as to the supreme importance of Her Majesty's Government bringing a General Powers Bill into Parliament so as to afford facilities for the development of the telephone, not only in the Metropolis, but also with reference to inter-town services all over the country, whether by private companies or by the Government themselves."

He thought that that appeared to summarise the general view of the meeting.

Mr. JACKSON said he thought they would do well to see the Postmaster-General, particularly in reference to what the Duke of Marlborough had said—that he had heard that the Government intended to oppose the two Bills of the Companies. He thought it was very important in the interests of all present that they should ascertain what the Postmaster-General intended to do. He referred to the Association for the Protection of Telephone Subscribers, of the Committee of which he was a member, and stated that it was about to be registered as a Company, which would give them a *locus standi* before Parliament.

The CHAIRMAN stated that he thought it right to inform the meeting that, although he felt he could not grant the request, Colonel Jackson had expressed a desire to answer the remarks of Mr. Provand. He then put the resolution in the form he had suggested, and it was carried unanimously.

Various names were afterwards suggested for forming the deputation referred to, and the Chairman stated that they would be submitted to the Council of the Chamber.

The meeting then separated.

BOOKS, &c., RECEIVED.

"Modern Practice of the Electric Telegraph." By F. L. Pope (New York : D. Van Nostrand Company.)

"Continental Electric Light Central Stations." By Killingworth Hedges. (London : E. and F. N. Spon.)

"Laxton's Builders' Price Book for 1892." (London : Kelly and Co.)

City and South London Railway.—The Parliamentary estimates of the cost of extending the City and South London Railway to Islington have been prepared by Mr. J. H. Greathead. The length of this extension is given in these estimates as 2 miles 5 furlongs 3 chains, and the total cost is set down at £706,633. Of this sum, £330,540 will, it is estimated, be spent in tunnelling, £211,000 upon the acquisition of land and buildings, £81,600 upon stations, and £13,500 for the subway for foot passengers to and from Fish-street-hill. The laying of the permanent way will absorb £15,844.

LEGAL INTELLIGENCE.

Lane Fox v. Kensington and Knightsbridge Electric Lighting Company (Limited).

In this action the plaintiff claims an injunction restraining the Defendant Company from continuing to infringe letters patent,* of which he is the registered owner, for improvements in obtaining light by electricity, and in distributing currents for the same, and in the means and apparatus employed therein.

The Attorney-General (Sir R. Webster, Q.C., M.P.), Mr. J. F. Moulton, Q.C., and Mr. J. C. Graham, instructed by Messrs. Vandercorn, Hardy, Oatway and Doulton, appeared for the plaintiff. Sir Horace Davey, Q.C., M.P., Mr. Finlay. Q.C., M.P., and Mr. Roger W. Wallace, instructed by Messrs. Deacon, Gibson, and Medcalf, represented the Defendant Company.

The ATTORNEY-GENERAL, in opening the case for the plaintiff, said that this was a patent action of very great importance and of very great interest, but not either very complicated or at all difficult from the scientific point of view. Prior to the year 1878 there had been many attempts at electric lighting. They had been more or less successful, or rather, he should say, unsuccessful, in consequence of the difficulties which had arisen in finding a useful and commercial incandescent electric lamp. Prior to that time there was arc lighting. There was an intermediate stage of lighting when the Jablochkoff candle was used. Now the electric current could be generated in a variety of ways---notably in two ways—either from primary batteries or from dynamo machines. It was known at the time of the patent that you could generate a current of electricity by using a dynamo to send the current through the conductors. The conductors might be either continuous insulated wires going out and home, so that the current went right through the wire, and came back again through an insulated wire or at the other end, or at the further end the conductor might be sent to earth. "Earth" was a technical term known to electricians as any means of communicating or completing your circuit by an insulated conductor. Now having got the current generated in your conductor ready to do its work, it was necessary to fit in the lamps, and the way in which the lamps were proposed to be fitted in in all the systems at this time, was by means of what was called multiple arcs. Each of these little lamps formed a bridge, and through this bridge or across this bridge the current got back again to its destination. It must join the generator again, but instead of the lamps communicating with another conductor, they could all go to earth.

Mr. JUSTICE A. L. SMITH : What is the advantage of one over the other ?

The ATTORNEY-GENERAL : None whatever, except a question of safety from the Board of Trade point of view, or with reference to the disturbance of electric instruments in the proximity. You will be told that by the most skilled electricians.

Mr. JUSTICE A. L. SMITH : How do the Board of Trade want it to go back ?

The ATTORNEY-GENERAL : The Board of Trade expect you to have an insulated conductor going all the way, because it might be disturbing telephones, or a danger, or something else. It has nothing in the world to do with this invention, my lord. The system of lighting is perfectly useful, and, from an inventive point of view, complete, if all the conductors are taken to earth. It is a point of very great importance, and very likely a point of attack from my learned friend's point of view presently, when we understand the specification.

Things which are called secondary batteries were known for many years before 1878. Secondary batteries were batteries which stored up electricity and gave it out again when required. They were the invention of a most distinguished man named Planté. They were perfectly well known for years before 1878, but strangely enough people imagined what they are now finding out to be quite incorrect, that Planté's batteries were not sufficient and useful to do the work.

Mr. St. George Lane Fox was an electrician of the very greatest capacity and ability and of extraordinary foresight. He was no mere outsider who had made something which could not be worked, he was unquestionably far in advance of his time with regard to what he discovered as being practical, and that, both from experiments from actual user, and from trying the things himself. He knew all the theory, and proceeded to patent the first practical system and the first practicable means of successful electric lighting. The one thing that is necessary is to keep a constant current going through the lamps. If you had a lamp with a filament designed to carry a current at 100 volts, and you put 120 volts on it, the lamp would break down at once—that is to say, the current would be too strong, and the bridge would be broken down by the pressure being too great for it. Therefore, there were two reasons why the current should be kept constant ; the one that the lamp might not break down from excess, the other that the lamp might give a proper illumination, and prevent the current from getting too low Mr. Lane Fox conceived the idea, that if he interposed secondary batteries in his circuit between the generator and earth he would get a constant pressure. It was not saying too much to say that that discovery of Mr. Lane Fox had solved the difficulty of electric lighting. It was not saying too much to say that, remarkable as it may be, every system of modern successful electric lighting which proceeded from generators, dynamos, and which was absolutely maintained at a constant pressure was an exemplification of Mr. Lane Fox's discovery and system. The specification was dated October 9, 1878. It was entitled "improvements in obtaining light by electricity, and in conveying, distributing, measuring, and regulating the electric current for the same and in the means or apparatus employed therein." Mr. Lane Fox described a new kind of lamp. He need mention

* No. 3988.** 1878.

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no more with regard to that lamp than to say that it was a lamp of which the conductor was platinum or iridium. It was a perfectly successful lamp from an electric lighting point of view, but it was commercially nothing like as good as a carbon conductor, and Mr. Lane Fox subsequently disclaimed that lamp. The only importance with reference to the present controversy was that it was an incandescent lamp. The Attorney-General proceeded to quote further from the specification: "The way in which I work a number of these lamps from a single source of electricity is as follows: From one pole or electrode of the electric generator or generators proceeds a large conductor, from which branch out at various points, where lights are desired, smaller conductors, which again may have conductors branching off from them and so on." It had been called a tree system—a trunk and branches. It was an identical parallel to a trunk and branches of trees. "The other pole or electrode of each electric generator is connected with the earth, so that the conductor and its branches and sub-branches will be perpetually in a state of electric tension tending to develop currents in every direction to the earth."

Mr. JUSTICE A. L. SMITH: Do I understand that it would have been just the same if they had brought it back by return conductor?

The ATTORNEY-GENERAL: Certainly, my lord, exactly—just the same. That will be the essence of my contest—identically the same from an electrical point of view, and from a practical working point of view, if brought back through a return conductor.

Mr. JUSTICE A. L. SMITH: Why does that controversy arise—in what way?

The ATTORNEY-GENERAL: It does not arise in any way unless the defendants suggest that a return to earth does not make the system which Mr. Lane Fox is describing a working system. That is the only way in which it can arise. "One pole of the electric lamp is connected with the earth, and this may be conveniently effected by means of gas or water-pipes where such exist"—that merely meant that instead of taking the wire down into the earth itself, you might take it joined on to a gas or water-pipe which went into the earth—'so that wherever the circuit is complete between the earth and any one of these branches, a current of electricity will pass through the thin leaf of metal"—that was the con-

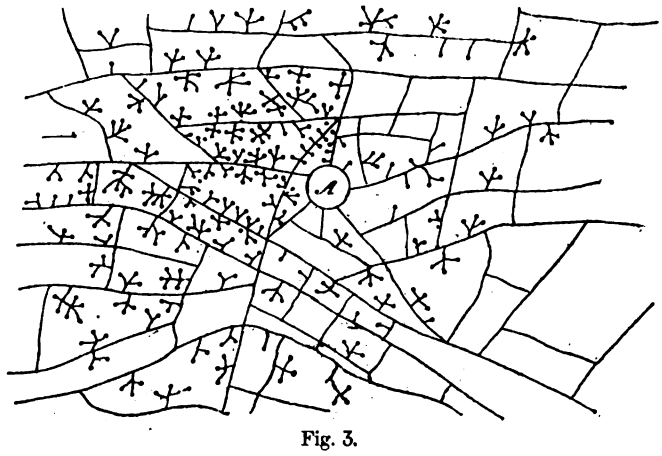

Fig. 3.

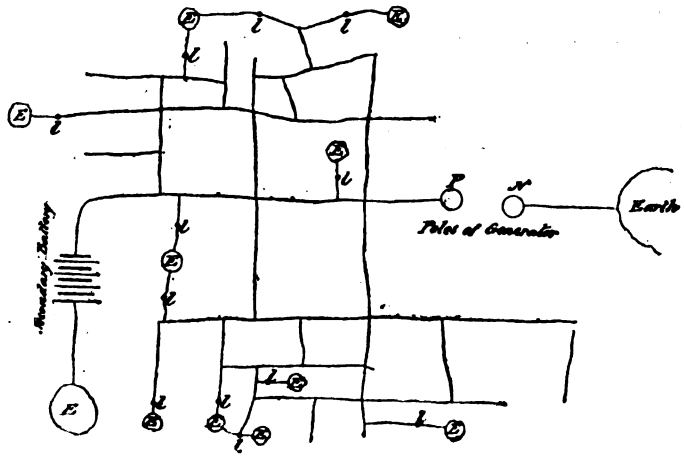

Fig. 5.

ductor inside the lamp—"rendering it incandescent, and so produce light." "The electromotive force of the electric-conducting mains should be kept as nearly as possible constant at, say, 100 volts, or British Association units, of electromotive force." It had really a very important bearing upon this gentleman's knowledge that that which was enunciated in 1878 was to-day the best electromotive force for working lamps in any system which had been devised. "A number of Planté's (lead and sulphuric acid) cells joined together in series between the main and the earth will serve as a kind of reservoir for the electricity. The electric current may be conducted through copper conductors, which can conveniently be laid inside the existing gas-pipes, having insulators of earthenware or other material around them to prevent their contact with the iron pipes." "In order to keep the electromotive force in the electric mains constant it is desirable to have in the first place several generating machines: next, it is necessary to have some regulator such as that about to be described." Then he described a regulator. It would be contended by his learned friend that that prevented Mr. Lane Fox from saying that he used his secondary batteries as regulators, because they would say he was indicating another kind of regulator; but it would be proved that the regulator which was referred to at line 47, was a regulator for keeping the steam which drives the engine constant, or rather for keeping the amount of current which came out from the generator free from the fluctuations which would result from a different pressure of steam. Line 11 on page 4, read as follows: "The way in which I distribute the electric energy so as to work a number of these lamps from a single source of electricity is represented in the diagrams, Figs. 3 and 5, and is as follows: From one pole or electrode of the electric generator or generators (situated at *A*, Fig. 3), proceed one or more large conductors from which branch out, at various points where lights are desired, smaller conductors, which again may have conductors branching off from them, and so on. The other pole or electrode of each electric generator is connected with the earth—so that the conductor and its branches and sub-branches will be perpetually in a state of electric tension tending to develop currents in every direction to the earth. One pole of the electric lamp is connected with the earth *E*. A number of secondary batteries, such as Planté's (lead and sulphuric acid), such batteries being joined together in series between the main and the earth, will serve as a kind of reservoir for the electricity. The cells should have a very large conducting surface, and there should be several batteries connected up at various points of the mains, so that by increasing the electromotive force during the hours when not much electricity is being used they will become charged and the electric force will be stored up in them, so that a sufficient supply will be available when the electromotive force falls owing to the draft from the mains when the force is most used and needed. The number of cells in each of these batteries will depend on the electromotive force of the mains." This was a unique declaration as to the use of secondary batteries—absolutely unique. All kinds of publications were suggested by the defendants in this case, alleging that Mr. Lane Fox told the people no more than people knew before. That was a question of evidence, but he asserted that it was a unique enunciation, absolutely new, of the utility of, and the function to be performed by, secondary batteries. Mr. Lane Fox—wisely advised, from his point of view—threw overboard everything which it could be said might involve considerations except the use of his secondary batteries. He disclaimed the lamp. The regulator for regulating the steam was found not to be essential. Accordingly, he threw that overboard. Everything was cut out but the one essential novelty, which was "employment as described of secondary batteries as reservoirs of electricity in combination, with a mode or system of distribution, such as is hereinbefore explained." No doubt his lordship would wonder why this having been patented in 1878, they were fighting the case in the year 1892. The fact was Mr. Lane Fox was not a rich man. A full explanation will be given on any point as to the question of delay. The case depends entirely on the electrical evidence as to the existing state of knowledge at the date of the specification; and then it is for your lordship's construction of the specification. You will hear from the evidence what the defendants did. I shall ask your Lordship to listen with the greatest care, as I know you will do, to this. Mr. Lane Fox had to fight a combination of electric lighting companies. He made no complaint of it. Other people had recognised, but these people had declined to recognise, Mr. Lane Fox's rights.

Prof. JOHN PERRY (examined by Mr. J. C. Graham) said that he had very great experience in electrical engineering long prior to 1878, and was familiar with the state of electrical knowledge about the year 1878. The secondary battery prevented flickering of the light. That was, it regulated the supply when the dynamo was in use. When the engine which drove the dynamo went a little too fast, so that the pressure in the mains tended to be too great for the lamps, the battery stored the surplus supply of energy, When the dynamo went too slowly, giving out too little energy, the battery unstored and helped the dynamo. Precisely the same effects occurred when you altered the number of lamps that the engine was supplying. He considered the system described quite novel. It was now being used, and was a very useful invention. He knew of no description prior to Mr. Lane Fox's, or any use prior to Mr. Lane Fox's battery of secondary batteries, for the purpose of compensating the tendency to variations of pressure on the main.

Mr. JUSTICE SMITH: What were secondary batteries used for, then, before 1878?—For producing certain momentary effects.

Mr. GRAHAM: They loaded the secondary battery like a gun, and then let it off with a bang. That is what we are speaking of?—Yes.

What are the conditions that you found in Lane Fox's system which are meritorious in your mind?—

Mr. JUSTICE SMITH: If this evidence be right—I am sure I do not know whether it is right or wrong yet—but if it be right, you have plenty of merit in it, because it produces a flame that does not flicker. There is plenty of merit there. You do not want any more as regards myself. I do not know about the Court of Appeal, but if it is true I should think there was ample merit to have a steady light instead of one going up and down.

WITNESS continuing, stated that "earth" was the technical term for a return conductor, for a return however obtained. Metal return wires were also usually called "earth."

Cross-examined by Mr. FINLAY: You mentioned, I think, as the advantage of this patent that it would prevent flickering?—Yes.

Would you turn to the patent? You have the patent as amended on disclaimer. I will take it in its final form at page 4. Does not that point to the storing up of the electricity during the daytime for use at night,

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a recommendation in favour of urging Government "to confer statutory powers" upon Telephone Companies.

The paragraph in question, however, is not very clear, and might be read as if the resolution were in favour of conferring such powers upon some particular company. It is evident that the Chamber, in passing any resolution of this kind, cannot act in the interest of any one company but of all telephone companies, formed or to be formed, without distinction.

I should be glad if you will kindly insert this correction, as a misapprehension appears to have arisen.—I am, Sir, &c.,

KENRIC B. MURRAY, Secretary.

February 19, 1892.

JOHNSTONE'S SYSTEM OF ELECTRICAL UNDERGROUND CONDUITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 19th inst., in which you give an account of the above system of underground conduits, you say that we appear to be "very much averse to the use of lead-covered cables." We wish to correct this statement, and to point out that what we maintain is, that lead-covered cables in an *insulated* conduit are dangerous, but in a cast-iron system, such as Johnstone's, there is no possible reason why they should not be used if desired. As a matter of fact, in America, where there are about 150 miles of duct in operation, nearly all those in New York are lead-covered, as is customary there. —We are, Sir, &c.,

THE INTERNATIONAL ELECTRIC SUBWAY COMPANY (LIMITED).

TRADE NOTES AND NOTICES.

TENDERS INVITED.—The Guardians of Wellington (Salop) Union invite tenders for providing and fitting a complete telephonic installation at their workhouse at Wellington, Salop. The installation is to consist of one centre and four sub-stations. Tenders are to be sent in to Mr. John Jones, clerk to the Guardians, not later than Wednesday, March 9th, and a copy of the specification may be seen at the workhouse. Further particulars are given in our advertisement columns, and full information can be obtained upon application to Mr. John Jones as above.

THOMSON-HOUSTON INTERNATIONAL ELECTRIC COMPANY.—This Company notify us that they have now transferred to the Union Electricitäts Gesellschaft, Berlin, their business in Germany, Austria-Hungary, European and Asiatic Russia, Finland, Sweden, Norway, Denmark, Holland, Belgium, Switzerland, Turkey, and the Balkan States; and that all business connected with the introduction and use of the Thomson-Houston systems of electric lighting, power, tramways and mining apparatus in the countries referred to will be dealt with by the Berlin house. The manager hitherto of the Hamburg office of the Thomson-Houston International Company, Mr. Louis J. Magee, will take an active part in the management of the new company as its technical director. All business in Europe in countries other than those named remains under the direct management of the Thomson-Houston International Electric Company, and will be dealt with from the General European office of the Company, No. 7, Rue du Louvre, Paris, from which office all information and estimates will be furnished. Mr. E. Thurnauer, who for several years has been in charge of the Paris office of the Thomson-Houston International Electric Company, has been appointed by the Board of Directors the General European Manager of the Company, and will have sole charge of all its affairs in Continental Europe, Great Britain, and Ireland. The London offices of the Company will remain at 35, Parliament-street, Westminster, S.W., and Mr. W. S. Graff-Baker, who has been the representative of the Thomson-Houston Electric Traction System in Great Britain, will continue to devote himself exclusively to the introduction of the system; although the lighting business for England and Ireland will be conducted as hitherto by the Laing, Wharton, and Down Construction Syndicate Limited), at 38, Parliament-street, S.W.

JOHANNESBURG.—Messrs. Woodhouse and Rawson United (Limited) send us particulars of the work done by their Johannesburg branch during the past year, which includes the first contract for the lighting of Johannesburg by means of arc lamps, which has now been running for some time; the lighting both above and below ground of the City and Suburban Gold Mining Company (Limited), Metropolitan Gold Mining Company, battery house of the Van Ryn Gold Mining Company, and the supplying direct of plant for each installation. The Company have also prepared the plans and specifications for the lighting of Pretoria, and supervised the erection of buildings, machinery, &c. Miscellaneous lighting contracts include that of the Globe Theatre, and the firm have also prepared plans and specifications for transmission of power for the Moodie's Gold Mining and Exploration Company. Sub-agencies and stores have been opened at Cape Town, Kimberley, Barberton, Pretoria, Maritzburg, and Durban.

MESSRS. HODGES AND TODD.—In our last issue we notified that a fire had recently taken place at Messrs. Hodges and Todd's premises in the Gray's Inn-road, London, W.C. We are now informed that the firm have taken new premises at 19, Kirby-street, Hatton Garden, E.C., and that they will shortly be in a position to supply their manufactures as before. We are asked to state that, contrary to some reports that have been circulated, the fire did not originate on Messrs. Hodges and Todd's premises.

GENERAL ELECTRIC COMPANY (LIMITED).—This Company have just issued the 9th edition of their catalogue of electric bells and accessories, lightning conductors, &c., and they are to be complimented upon the completeness of the book, which can safely be recommended to the trade as containing very full particulars of all this firm's manufactures. In addition to the large number of illustrations, instructions are given at the end of the catalogue for fixing and connecting electric bells, &c.

MR. A. P. LUNDBERG.—We have received from Mr. Lundberg his new catalogue and price list of electric light switches and fittings. Amongst the illustrations are shown the "Unique," the "Midget," the "Pioneer," the "Universal," the "Ridge," the "Premier," and the "Main" switches, the "Unique" combination switch wall socket, and the "Secure" ceiling rose.

PORTSMOUTH AND SOUTH HANTS ELECTRICITY SUPPLY COMPANY, LIMITED (IN LIQUIDATION).—A meeting of the shareholders is to be held at 46, St. James-street, Portsea, on March 21st, at 11, to receive the liquidator's account of the winding up.

DISSOLUTIONS OF PARTNERSHIP.—Messrs. Chant and Crawford, trading as Dollond and Co., electrical and scientific apparatus makers, Ludgate Hill, E.C. Mr. Tyson Crawford will pay all debts and continue the business.——Messrs. Dawson and East, electricians, 51, Newington-butts, S.E. Mr. G. E. East, junr., will continue the business.——Messrs. D. and G. Graham, electrical engineers, Glasgow, by the retiral of Mr. R. McPherson. The business will be carried on under the same title by Mr. John Scott, who will pay all debts.

COMPANIES' MEETINGS & REPORTS.

Westminster Electric Supply Corporation (Limited).

The ordinary general meeting of the shareholders of this Company was held on Wednesday at the Westminster Palace Hotel, Victoria-street, under the presidency of the Right Hon. Lord Suffield, K.C.B.

The SECRETARY (Mr. Frank Iago) having read the notice calling the meeting,

The CHAIRMAN said: I regret to say, gentlemen, that I am not yet sufficiently recovered from the severe illness which I have had to address you as I should have liked to do, and to answer those questions which, no doubt, you will be anxious to put. Therefore, will you allow me formally to move the adoption of the report and accounts? and I will ask my friend, Mr. Powell, to do my duty for me on this occasion, as far as explanations may go.

Mr. POWELL: My lord, before I proceed to make any remarks on the report and accounts, I am only speaking the wish of the Directors, and I am sure of all the shareholders, that you may speedily be restored to health. We have been greatly pained by the news of your long-continued illness, and we hope, now that you have come among us again, that you will soon become as strong as you have ever been in your life. I apprehend that the shareholders will take the report and accounts as read. We have now the pleasure of congratulating you upon the possession of three central stations: one in Millbank-street, which is practically completed—in fact, I do not think any more payments will have to be made in regard to this station except for some condensing apparatus; then we have the central station at Eccleston-place, which, so far as the plant and works are concerned, is almost complete; and the third station is that at Davies-street, which is almost in a similar state. At Eccleston-place we are making provision for the offices of the Company—for the secretary's office, for the offices of the engineer and his assistants, and a board room; and the erection of these buildings will be completed for an amount, the interest upon which will be very considerably less than the rental which we are paying for somewhat inconvenient premises in Victoria-street. At Davies-street we are covering the frontage with flats or chambers, erected at no very large cost, and we expect a very considerable rental from them. The buildings have all been put up in the most substantial way, and I hope that any shareholders who have the opportunity of doing so will go and see for themselves how we have combined the very best construction without being at all extravagant. I think you will all say if you see those buildings that they are an ornament to the neighbourhood in which they are situate, and I believe that they will be surrounded by buildings of a similar character. The

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greatest care has been taken by our engineer to put up machinery of the best description at the lowest possible cost; and I believe it has been done most economically. We have, however, arrived at this result after a great many drawbacks. In the first place, our architect tells me that we were delayed at least 66 days by the severe frost of 1891; and, moreover, the carpenters' strike of that year delayed the Davies-street building at least six months. Yet, notwithstanding these great drawbacks, the promise which we held out at our last general meeting, that we should be able to work Eccleston-place within about a fortnight, was fulfilled more than to the letter. Within a week of that meeting we were able to start Eccleston-place by March 2nd, and on March 4th we were able to supply the light for Her Majesty's Drawing-room, with, I believe, as much perfection as characterises any of our lighting. Then, I must tell you that at the end of February of last year we had only 13,140 lamps on circuit; and to show you how the electric light current was wanted, we found that in March there was an increase of 5,842 lamps, in April of 9,992, and in May of 6,789—that is to say, an increase, in round numbers, of 22,000 lamps over the number we were supplying at the end of February; and by the end of June we were supplying about 37,000 lamps, or, in round numbers, about three times the number we had been supplying in February. When June came, however, sunlight was beginning to take the place of electricity. People were beginning to think of leaving their town residences; and notwithstanding the great increase in the number of our lamps, we found that our revenue did not increase in like proportion. The number of lamps, however, still went on increasing. In June there was an increase of 1,500 odd, in July the increase was 2,700 odd, and in August there were 2,500 more. The days then got shorter, and the increase became larger still—namely, 4,900 in the month of September. Altogether, therefore we had an increase of 11,692 lamps in these four months, which I think was very gratifying under the circumstances. Still, we found that there was no increase of revenue. The sun kept on and the people kept away; and it was not until October that we began to realise the great increase we had made in our business, while it was not until December that we found that fog was our best friend, which I believe it will always prove to be. In one week of fog our receipts increased from £800 to £1,200, or 50 per cent. Of course, this put a very heavy strain on our engineer, and all who worked under him; but I am happy to say that the supply in that week was as good as it had ever been, and it is the more gratifying for me to say that when the fog ceased, and the receipts for lighting fell down from £1,200 to their normal amount of £800, the expenses seemed to decrease almost automatically. The figures I have given you will explain why the income we showed on the 31st of December last is so small, because during the first part of the year we had comparatively few lights, and it was only as the season went on that the great increase took place; and again, it was only in November and December that we saw what a valuable business we had. Now, it may be interesting to you to know what is likely to be our income from our present circuit of lamps. I take our present circuit at the very low figure of 68,000 lamps. I may tell you that since the 31st of December the number of lamps lighted has so largely increased that we have arrived now at 75,253; but I will take the very moderate figure of 68,000, and I will take the still more moderate estimate of 10s. per lamp. That basis will show you an annual income of £34,000, instead of the comparatively small income shown in our published accounts of £19,000. Upon a lamp circuit of 68,000 we shall have an increase of revenue of £15,000; and these figures are, of course, as I have already intimated, far within the mark. We find now that our increase per month of applications amounts to something like 4,000 lamps, and we see no reason why this figure should be less, although we can hardly expect that this year we shall gain the enormous increases which were shown during last year. I am quite satisfied of this—that if we supply a good light at a moderate price, people will see that electric lighting has become one of the necessities of the age—that it is necessary for people's comfort in their houses, and that it is also most necessary for the conduct of business. In my very small experience I occasionally go to hotels, and I always choose those which have the electric light. I find that it is the best light, that it gives the least unpleasant heat, and that there are no unpleasant fumes from it. I believe that every hotel and club house will, within a very short time, be obliged to avail themselves of the light we offer them. I must again recall to your mind the very great disadvantages under which we have been during the past year. Any one who had gone to the Davies-street station this time last year would have said that it was utterly impossible for us to supply the electric light from that station for several months. Everything there was in the greatest confusion. There were a great number of excavators there, and bricklayers and labourers; and you know from your own experience in private houses how much dust there is about in connection with such work, and how destructive is the dust which they cause to machinery. Nevertheless, when we saw the very large business that was offered to us, as is shown in our monthly increases, we thought it was wise, in your interest, to put up a temporary building, and to work this business at any reasonable cost. The cost, I confess, was great, but I think the advantages were far out of proportion to the cost of producing the light. Now, having so far descanted upon what has taken place and what are our probable requirements, it may naturally occur to many of you to ask me what provision we have made for the future. I think I can tell you tolerably accurately. We find that we are supplying—or we were supplying—about 68,000 lamps. In our present premises, with our existing machinery, placed or in order, we have accommodation for about 130,000 lamps. If the space at our disposal within the existing buildings were utilised, we could supply from Millbank-street 30,000 more lamps, Eccleston-place 60,000 more, and Davies-street 75,000 more, so that altogether the existing premises could supply 165,000 lamps. That brings up our opportunities of supply to 295,000 lamps, which I will take to be, in round numbers, about four times our present output. But that is not the measure of what we can do. We find that at Eccleston-place we have very considerable space in addition, so that when the time comes we shall be able to enlarge our buildings to a corresponding extent: and I believe we shall be able to some extent to enlarge our buildings at Millbank-street. Altogether I believe that with our extra space we shall be able to supply about double the figures I have mentioned (295,000 lamps); and this, I think, is very satisfactory. I may tell you that at Eccleston-place it is probable we shall have to put up a little more machinery in order to accommodate the extra number of lamps, and I think it is not unlikely that we shall have to work Eccleston-place hard when we get to the end of our tether. I look upon it that the time must come, if Mayfair goes on as it has been, that we shall have to provide further accommodation for the Mayfair district. I will not go on with these observations any further, but I will take you to something which is more immediately pressing—that is, the amount which we shall have to allow for depreciation of machinery. You will see that in this account we have allowed £1,000, which we considered to be both fair and ample. Our machinery is new, and a great deal of it was not thoroughly worked until towards the end of the year. Nevertheless, everything wears as soon as it is put into work—as we ourselves do—and we thought it was only right that we should put a certain sum against depreciation of machinery. I must not, however, deceive you by letting you suppose that £1,000 will in any way be sufficient for the depreciation which we are likely to set against our revenue; and upon this matter I will quote from the report of our engineer, on which I believe you may thoroughly rely. He says: "I think it would be wise not to allow less than, say, £100 per week, to be set apart for depreciation, paying all maintenance charges out of revenue, in order that the Corporation may be able to meet the possibility of some new invention or improvement being so rapidly matured as to make some of our machinery prematurely obsolete, a contingency which cannot otherwise be provided for." He (the speaker) might say that their machinery now was of the very best and newest description, but electric lighting being a new invention, there was no knowing what development might take place and, therefore, he quite agreed with their engineer. He felt that he ought not to make such a remark as that he agreed with their engineer, because he was himself no one in such a matter as this, while their engineer was everyone; but he thoroughly concurred in what Prof. Kennedy said. In his report, their engineer continued: "So far as we at present know, there is no astonishing economy to be made in cost of production of the electric light. There are many economies in detail, of course, and especially cost of production will be greatly reduced as the total output increases; but all the economies before us at present must be simply the straightforward results of thoroughly good management and unremitting attention to all sorts of details. If some happy inventor succeeds in showing us how to produce light by electricity without simultaneously producing heat, there would at once be an enormous saving. Many inventors have been at work on this for a long time, but as yet without attaining any results, so far as I know, which have the slightest commercial importance. No one, however, can deny the possibility that within a reasonable number of years some such discovery may be made, although at present the very best work that has been done does not seem to have pointed out to us the right path. It is right to remember, however, that in any case boilers, steam pipes, engines, mains, and dynamos will all be required, whatever system may be the system of the future, and that although in all probability the dynamos would be quite different from those at present in use, the rest of the plant might quite possibly remain unaltered. In any case, the change of dynamos would be a change common to every supply company, and not peculiar to our own, so that we shall still be in quite as good a position as any other company." This figure of £100 has not been adopted by the Board; but I may say that we have such very great confidence in Professor Kennedy's figures that I do not doubt that we shall have to adopt them and the policy which he recommends. The tax on the energies of the Board during the construction of the works has been very heavy, and it is no small credit to those who started this Company—of whom I was not one—that they so accurately calculated the requirements of the district. They said it would require £300,000 to start this business, and we have managed to keep within that mark for the districts that were allotted to us. I should not be doing my duty if I were to claim for myself (and I am sure my colleagues would not for a moment wish to take it for themselves) the credit for these results. They have mainly been produced by the foresight, the constructive power, and the unfailing energy of Prof. Kennedy. It would be wrong of me to attempt to take credit for anything of this kind unless I put his name prominently before you. He has always kept his work well within his estimates. Not only have I been struck with his accuracy in figures, his power of design, but by his readiness to take advantage of every appliance whichhas been invented to reduce the cost of working. I should say that no Company has carried out similar works at a less cost or with greater success; and I believe that no Company within two years of its active existence has been able to supply the public with so many lamps, and so well. For that result you should in a great measure thank Prof. Kennedy. I must also single out your architect, Mr. C. S. Peach, for much praise. He has evidently entered into the spirit which has throughout animated this Board. He has worked well and cordially with Prof. Kennedy, and in every dispute that we have had—and people having to erect large buildings cannot avoid having disputes with adjoining owners—he has not only kept us free from litigation, but with the help of the common sense which he always carried about with him he has succeeded in making very good settlements for us. I must also say a few words of praise of Captain Bax, our manager, and our whole staff. Captain Bax has been most successful in obtaining customers and in dealing with them after we have obtained them. Now that our business is likely to be one more concerning administration than construction, I believe that Captain Bax will cordially work with us, and will be a grand helping hand towards carrying on the policy which Prof.

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Kennedy has put forth in the report from which I have quoted to you. You will see on the wall a diagram showing the lighting we supply, the number of lamps, and the revenue; and the diagram bears out what I have told you already on these points. I have only a few other remarks to make to you, which will be chiefly in answer to a shareholder who has written to the secretary, and who wishes me to answer the question at the meeting—that is, how it is that our cost of generating electricity appears to be so high in comparison with the cost in the case of another company. Well, the reason is that that other Company began with a good business at the beginning of 1891, and that we, as you can see from the diagram, had hardly any business at all. During the whole of the year, however, we were obliged to have an engineering staff to do our small business, and it was not until we got to September or October that we paid our expenses. It could not be otherwise. We had three stations, three resident engineers, as well as a number of people about us we could not discharge—in fact we could not have carried on our business as we did, if we had not had those people about us. Therefore the cost of generating electricity appears comparatively high, but if you will go into the details, you will find our cost quite as low as theirs, and that the explanation which I have given you is ample for its purpose. I have nothing further to say. As you know, Lord Suffield has been very ill, and has been unable to undertake the duties which he so punctually discharges when he is well and in good health. I will now conclude, in seconding the motion for the adoption of the report, by saying that if any gentleman desires any explanation of the report and accounts my colleagues or myself will be most happy to give it.

Mr. WILLIAM COOPER, referring to the issue of debentures, said that nearly £30,000 appeared to have been allotted. He wished to know whether there was any great necessity for raising these debentures, seeing that in the general balance-sheet an advance of £30,000 appeared to have been made to some individual or individuals on loans. It seemed to him extraordinary that they should raise £30,000 at 5 per cent. interest, and create a permanent charge of £1,500 a-year, while they lent with the other hand what he presumed was a temporary loan. He also thought that the debentures, instead of having been allotted to applicants, should have been issued *pro rata* to the holders of shares in the Company.

Mr. POWELL: The hon. proprietor is under an entire misapprehension. At the time we borrowed money on debentures we absolutely wanted it. If we had not done so we must have stopped our works. At that time we had not issued the remaining share capital. When it was found that the works were being so rapidly pressed forward and that our lighting was increasing so very satisfactorily, people came forward and took up the remaining shares. The money was paid up for those shares, if I am correct, on the 15th of October last, but it was paid up before we actually wanted the money, and therefore, as prudent men, we had to lend that money temporarily from week to week or month to month, or by a deposit to our bankers, so as to make something out of it. It is, however, an erroneous idea to suppose that we were getting this small sum of interest for our money. At the time we actually wanted the money, as our remaining share capital was not issued. These debentures, too, are terminable in ten years, and we were really thankful at the time for people to come forward and lend us money on the terms on which we issued them.

Mr. E. P. REED said he believed it was a fact that at the time the debentures were issued their shares were unissuable at par, and were quoted in the market at a discount. In that case it was the cheapest way of proceeding to issue debentures.

Mr. COOPER said he was abroad for seven months last year, and he had no idea that the debentures were issued before the remaining share capital was placed.

Mr. FITCH stated that their coal had cost them £700 more, and their oil and water £300 more, proportionately, than the other company he had alluded to in his letter.

Prof. KENNEDY: Your figures are perfectly right. Our figures are for a whole year's working, but they cover a time of year when we were working by no means economically—that is to say, at the beginning of the year we had a temporary station at Davies-street, which was using 50 per cent. more coal per unit than we are using now; and when we first started at Ecclestone-place and Davies-street they also used, for the first three months, much more coal in proportion than they do now. You are also comparing—quite rightly—the working of this Company, beginning with 10,000 lamps in February, with the working of a Company which began with 30,000 lamps in January. That reduces the cost of wages and of coals also enormously in proportion. I have been through the accounts very carefully, and the cost for the last two quarters, when we have had a considerable number of lamps on, for coal, has been precisely that of the company you named. The total sum paid by us and by them per unit—as nearly as I can estimate their unit—has been the same; while the cost of water and oil has been a little less with us. I trust next year that we shall be much the most economical of any of the companies, but it is not quite a proper comparison to compare a year which has six months when we were working upwards and against great difficulty, with a year such as 1892, when we began fairly.

The CHAIRMAN then put the resolution, which was unanimously adopted.

Mr. HAMILTON was understood to ask when a dividend would be paid.

Mr. POWELL: We generally deal with facts and not with prophecies; and I would rather wait and see the result of six months' working. As soon as it is possible to declare a dividend we shall do so.

The CHAIRMAN: I think the proprietor will see that we are in a fair way to success, and he can therefore draw his own conclusions.

Mr. REED moved, and Mr. STRATTEN BOULNOIS seconded, the re-election of Messrs. Cooper Bros. and Co. as auditors to the Company.

The CHAIRMAN put the motion to the meeting, and having declared it carried unanimously, stated that that terminated the business of the meeting.

Professor KENNEDY: May I say, before the shareholders go, that our stations are open to their inspection? Some of you were good enough to come with me last year to Millbank-street. All the stations are now at work, and if you have time to spare to visit Eccleston-place, which is about two minutes past Victoria station, or the Davies-street station, I think you would find that either place was worth seeing. They are both in full work.

Mr. MARK STEWART, M.P., proposed a vote of thanks to the Chairman for presiding, especially under the circumstances in which he had occupied the chair, and also to the Board for the clear and lucid manner in which explanations had been given on the affairs of the Company.

Mr. COOPER briefly seconded the motion, which was unanimously adopted.

The CHAIRMAN acknowledged the vote, and the proceedings then terminated.

Birmingham Electric Supply Company (Limited).

The second annual meeting of this Company was held on the 18th inst. at the offices of the Company at Birmingham, Mr. H. Buckley presiding.

The CHAIRMAN, in moving the adoption of the report (which appeared in last week's *Electrician*), said the close of the financial year was altered from the 31st March to 31st December to meet the requirements of the Board of Trade. The accounts showed a profit of £713. 16s. 4d.; but although the number of lights on the 31st December was 5,480, that was not the number of lamps earning an income during the nine months. The average number of lamps was 3.135, or, in other words, the earning power of the 5,480 lamps was only for 5·15 months. They commenced in April with 795 lamps only, but that number increased to 5.192 lamps earning an income, although there were 5,480 on order. At the present time there were more than 6,100 lamps. The current had been taken by various classes of the community, including hotels, clubs, public buildings, institutions, restaurants, shops, banks, insurance offices, general offices, and a theatre. The demand for the light had been most satisfactory, and during the coming year it would be necessary to extend their mains and make some increase in their engines and dynamos, in order to be prepared for an extension of their business, and to meet any temporary difficulty which might occur through their plant getting out of repair.

Mr. C. A. HARRISON seconded the resolution, which was carried.

Messrs. J. F. Albright and G. H. Johnstone were re-elected Directors, and Messrs. Sharp, Parsons and Co. were reappointed auditors.

India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

The twenty-eighth ordinary general meeting of the shareholders of this Company was held on Tuesday last, at the City Terminus Hotel, Cannon-street, under the presidency of Mr. S. Wm. Silver.

The SECRETARY (Mr. William J. Tyler) read the notice convening the meeting, the report of the Directors and statement of accounts being taken as read.

The CHAIRMAN: Gentlemen, I rise to move—

"*That the report be received and adopted, and a dividend of 10s. per share and a bonus of 5s. per share be paid forthwith, free of income tax, which, with the interim dividend paid in July, will amount in all to 12½ per cent. for the past year.*"

The amount carried forward is £42,000 odd, and the net profit is £79,102, after adding £25,000 to the reserve fund. Now, I wish to impress upon you the fact that the amount of our share capital is very small when we consider the nature and extent of our business. By looking at the accounts you will see that the first item of our assets and expenditure is £70,000 more than the whole of our share capital. Some shareholders do not see the advantage of our reserve fund, but it is necessary. In fact, the working capital, with the reserve added, is too small to enable us to undertake extensive contracts when offered. You must remember that cable contracts are generally large, and when two or three come to be open for tender at the same time the contractors need a large command of capital to deal with them. Now, taking all this into consideration, we think the time has come for our setting to work to increase still further our capital, and our present intention is to issue some new shares. Of course we shall issue them at a premium, and we propose to offer them to the shareholders in proportion to their holdings, so as to give to each shareholder an advantageous opportunity of increasing his stake in the Company. The machinery and buildings both here and in France are now so complete as to put us in a very favourable position as manufacturers. After these remarks I will merely add that our prospects are very encouraging, and that it is my painful duty to inform you of the death only last week of my old and esteemed colleague Mr. Neil Bannatyne.

Mr. ABRAHAM SCOTT seconded the resolution.

A SHAREHOLDER asked whether the reserve fund was considered as such, or as part of the working capital. If it was the latter, they would have between £700,000 and £800,000, instead of £416,000, on which dividend was paid. This would only give them in reality about 7 per cent.

The CHAIRMAN, in reply, said that the reserve fund was clearly stated in the assets as an investment in premises and stock, &c.—in other words, working capital. The premises in Liverpool were included in the first item under assets and expenditure. They made one amount of the whole this year.

The resolution was carried unanimously.

The CHAIRMAN moved the re-election of the retiring Directors, Mr. A. Scott and Mr. A. W. Jarvis, M.P.

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The Hon. HENRY MARSHAM seconded the motion, which was carried unanimously.

The Company's auditor, Mr. J. Weise, was also re-appointed *nem. con.*

The CHAIRMAN, in replying to a vote of thanks unanimously accorded to himself and colleagues, said that such a mark of confidence would call forth renewed energies on their part to advance the interests of the Company.

Mr. MATTHEW GRAY, the Managing Director, also briefly responded, and the proceedings terminated.

Croydon Tramways Company.

The ordinary general meeting of this Company was held on Tuesday, at the Guildhall Tavern, Gresham-street, under the presidency of Mr. W. J. Carruthers-Wain, the Chairman of the Company. In moving the adoption of the report, the Chairman said he thought he might congratulate the shareholders upon the results achieved, having regard to all the circumstances of the case. In regard to the question of traction, the Directors had entered into an agreement with the Electric Tramcar Syndicate, under which that syndicate was to supply two cars to be worked by means of accumulators in turn with the horse cars working the ordinary service on the Thornton Heath lines; this Company paying a fixed sum per mile run to cover all costs of working, and including renewals and depreciation. They had had certain figures prepared showing the miles run by the electric cars since they began running. It had to be borne in mind that there were first of all various difficulties, which, of course, it would be evident to the technical mind had to be overcome, but the result had been that from the institution of these electric cars they had run 662 miles and had earned £39, which came out at the rate of 1s. 2¼d. per mile run, which he considered a marvellous return, and showed very satisfactorily in comparison with other modes of traction. He had no doubt that if this test of electric cars proved satisfactory upon the lines of this Company the Electric Traction Company would be disposed to enter into still larger arrangements for the conduct of traffic under their system. At present the work was being conducted under the principle that heads the tramway company won and tails they did not lose anything, because they were not in the position of having any money to lose or to risk in conducting a large electrical work upon their tramway. Their desire was to conduct the traffic in the most economical manner, and they were trying various means of motive power. They had recently adopted, in addition to the electrical system, a system known as the Connolly Motor. The prospects generally were encouraging, and he looked forward to the continued progress of the Company. Their relations with the local authorities, he was pleased to say, were most harmonious.

The report was adopted.

Exploration Company (Limited).

At the ordinary general meeting of this Company, held on Tuesday at Winchester House, Old Broad-street, Mr. Horace B. T. Farquhar presided.

The CHAIRMAN, in the course of his remarks, said, with reference to the Central London Railway, that he had no doubt the shareholders were all aware that two years ago some of their neighbours tried to get a Bill through Parliament to enable them to take up that project. They were, however, unsuccessful in their efforts, and last year the Board of the Exploration Company made up their minds to try themselves, as the business was a very desirable one, and one largely taken up by capitalists in America. A syndicate was formed for the purpose of running the risk and paying the law expenses and the costs of getting the Bill through Parliament; and he was happy to say that they were successful. The Bill received the Royal assent, and became law in August last. Things were now going on favourably, and before long, when financial matters improved, they would be able to carry the matter through successfully. Another company which they had been successful in floating had been the City of London Electric Lighting Company, which they brought out in conjunction with the Electric and General Investment Company.

Telegraph Construction and Maintenance Company (Limited).

The following is the report of the Directors of this Company to be submitted to the members at the twenty-eighth ordinary meeting, to be held at 38, Old Broad-street, E.C., on Tuesday, the 1st prox., at one o'clock:—

The accounts for the year show a net profit of £85,199. 8s. 5d., after charging the interest on the Debentures. To this sum must be added £61,524. 11s. 11d. brought forward from last year, making a total of £146,724. 0s. 4d. From this amount is deducted the interim dividend of 5 per cent. paid July 14, 1891, amounting to £22,410, leaving £124,314. 0s. 4d. to be dealt with. Of this sum the Directors propose to distribute a dividend of £1. 16s. per share, absorbing £67,230, being at the rate of 15 per cent., and making, with the amount already paid, a total dividend for the year of £2. 8s. per share, or 20 per cent., free of income tax, leaving £57,084. 0s. 4d. to be carried forward to the next account.

All the Company's steamships have been employed during portions of the year 1891 in laying or repairing submarine cables in various parts of the world.

Repairs have been effected in the Brazilian Submarine Telegraph Company's cables in the vicinity of Lisbon and Madeira, and in the Direct United States Company's cable on the coast of Nova Scotia. A duplicate cable has been laid for the Eastern Extension Telegraph Company between Madras and Penang, and a triplicate cable for the Eastern Telegraph Company between Aden and Bombay. A cable has also been laid for the Great Northern Telegraph Company between Oye, on the French coast, and Fanoe, on the coast of Denmark. During the year a length of 5,132 knots of telegraph wire has been insulated for submarine and land lines.

The Company's steamships, and factories at East Greenwich and Wharf-road, are in efficient condition.

The Directors regret to announce the death, on August 12th last, of Sir Thomas Fairbairn, Bart., who had served on the Board for a period of over 21 years. Their former colleague, Admiral of the Fleet Lord John Hay, G.C.B., being again free from service afloat, has been re-elected to a seat at the Board in the place of Sir Thomas Fairbairn.

The retiring Director is Mr. George William Campbell, who, being eligible, offers himself for re-election. The meeting will have to appoint auditors for the ensuing year. Mr. John Gane (of the firm of Messrs. Gane, Jackson and Jefferys) and Mr. Patrick A. Glegg (of the firm of Messrs. Welton, Jones and Co.), who retire, offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of the majority of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK.]

DALMATIAN EXPLORATION AND MINING SYNDICATE (LIMITED).—Among the objects of the above-named Company, which was registered on February 15th, with a capital of £500, in £1 shares, is included that of acquiring, manufacturing, working, letting out on hire, or otherwise dealing with or disposing of plant, machinery, apparatus, and materials for the production and distribution of electricity, and for the application of electricity to the separation of metals and ores, as well as for lighting, heating, or motive power, and to supply electricity. Presented for registration by Arnold, Williams, and Co., The Vestry House, Laurence Pountney-hill, E.C.

ELECTRO-AUTOMATIC FIRE EXTINGUISHING COMPANY (LIMITED).—This Company was registered on February 16th, with a capital of £12,500, divided in 6,940 ordinary, 5,500 cumulative preference, and 60 founders' shares of £1 each, by Fox and Joy, 59 and 69, Chancery-lane, W.C. The objects are to enter into and carry into effect an agreement which has already been prepared and is expressed to be made between C. M. Martin, of No. 8, Imperial-buildings, Holborn Viaduct, E.C., of the one part, and the above-named Company of the other part; or otherwise to acquire the exclusive licence mentioned in the said agreement or the letters patent mentioned in the schedule to such exclusive licence and all the extensions of the said letters patent or any of them; and to carry on the business of a manufacturer and vendor and lessor of fire checks or fire extinguishing apparatus and all materials and apparatus necessary for making the same. Registered without Articles of Association.

FLETCHER, RUSSELL AND CO. (LIMITED).—This Company was registered on February 16th, with a capital of £150,000, divided into 5,000 Six per Cent. Preference and 10,000 ordinary shares of £10 each, by Cunliffes and Davenport, 43, Chancery-lane, W.C. The objects are to acquire the goodwill of the businesses carried on at Warrington, in the County of Lancaster and elsewhere, under the style of Thomas Fletcher and Co., as gas engineers, and at Pendleton, near Manchester, in the said county, and elsewhere, under the style or firm of W. and A. C. Russell and Co., as artistic and general ironfounders, and to carry on the businesses of iron and metal founders, mechanical, gas, heating, lighting, ventilating, electrical and general engineers, iron and brass workers, machinists, tool makers, smiths, &c.

HARFIELD AND CO. (LIMITED).—This Company was registered on February 16th, with a capital of £100,000 in £10 shares, by Williams and James, Norfolk House, Thames Embankment, W.C. The objects are to acquire the business carried on by William Harfield and Co. at Mansion House-buildings in the City of London, and under the style or firm of the Blayden Ironworks, at Blayden-on-Tyne, and to carry on the business of mechanical engineers, machine and engineering tool makers, boiler makers, iron founders, brass founders, metal workers, electrical engineers and manufacturing chemists, &c.

DISTRICT MESSENGER SERVICE AND NEWS COMPANY (LIMITED).—The first annual return of the above-named Company, made up to January 14, 1892, was filed on February 8th. The Company was registered on June 30, 1890, with a nominal capital of £200,000, divided into 39,800 ordinary and 200 founders' shares of £5 each. Among the patents acquired were included the following:—An invention of "Improvements in Electrical Signalling Apparatus for Police Service and the like," for which provisional protection for the United Kingdom, No. 6,126, was granted to R. D. Radcliffe on April 22, 1890; and an invention for "Improvements in and relating to Printing Telegraphs, and to the Distribution of News transmitted thereby," for which provisional protection, No. 8,031, was granted to the said R. D. Radcliffe on May 22, 1890. At the time of making up, 12,567 ordinary and all the founders' shares were taken up, of which 7,411 ordinary and the 200 founders' shares were issued as fully paid. Upon 4,389 of the remaining ordinary shares £3 10s. per share has been called, and upon the remaining 767 ordinary shares £3 per share has been called, resulting in the payment of £14,923. 10s., and leaving £2,739 in arrears. Registered office: 50, Lime-street, London, E.C.

EASTERN TELEGRAPH COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 28, 1892, was filed on February 18th following. The Company was registered on June 6, 1872,

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with a capital of £3,800,000, in £10 shares (of which 339,700 shares were issued as fully paid up), to acquire the undertakings, telegraph lines, property, privileges, effects, obligations, and the liabilities of the following four companies, namely, the Anglo-Mediterranean Telegraph Company (Limited), the British Indian Submarine Telegraph Company (Limited), the Falmouth, Gibraltar, and Malta Telegraph Company (Limited), and the Marseilles, Algiers, and Malta Telegraph Company (Limited). The present nominal capital is £4,700,000, divided into 70,000 preference and 400,000 ordinary shares of £10 each. At the time of making up, 469,988 shares were taken up, the full amounts called on both preference and ordinary, and all calls paid. Registered office: Winchester House, 50, Old Broad-street, London, E.C.

J. E. H. GORDON AND COMPANY (LIMITED).—The first annual return of the above-named Company, made up to the 8th February, 1892, was filed on the 16th February following. The Company was registered on the 19th September, 1890, with a capital of £50,000 in £10 shares, to acquire and carry on the business of J. E. H. Gordon, electrical engineer. At the time of making up, all the shares were taken up, of which 3,000 were issued (2,000 to J. E. H. Gordon and 1,000 to W. J. Rivington) as fully paid in full satisfaction of the purchase consideration; upon the remaining 2,000 shares the full amount has been called, resulting in the payment of £19,970 and leaving £30 in arrears. The principal shareholders are J. E. H. Gordon, M.Inst.C.E. (2,150), W. J. Rivington (1,350), S. W. Searle (156), S. Woodhouse (300), S. H. Woodhouse (200), E. H. Fowle (645), and H. R. Bruxner (100). The following notice was filed on February 16, 1892:—"Notice of Increase of Capital of J. E. H. Gordon and Company (Limited). To the Registrar of Joint-Stock Companies. J. E. H. Gordon and Company (Limited) hereby give you notice, in accordance with 'The Companies Act, 1862,' that by a resolution of the Company, dated February 8, 1892, the nominal capital of the Company has been increased by the addition thereto of the sum of £50,000, divided into 5,000 shares of £10 each, beyond the registered capital of £50,000. Dated February 9, 1892. J. E. H. Gordon and Company (Limited), Hy. Sinclair, secretary." Registered office: 11, Pall-mall, London, S.W.

LAMP MANUFACTURING COMPANY (LIMITED).—The statutory return of the above-named Company, made up to date to January 3, 1891, was filed on November 24, 1891. The Company was established to acquire the patents and assets, and to carry on the business of Ridsdale's Railway Lamp and Lighting Company (Limited), and to carry on the business of manufacturers of, and dealers in, lamps of all kinds, and of apparatus connected with the manufacture, consumption, and supply of gas, oil, and electricity. The English and Scottish Trust (Limited), of 11, St. Helen's-place, London, E.C., are the largest shareholders. Registered office: 45, City-road, London, E.C.

MACMAHON'S PATENT ELECTRIC CHECK SYSTEM (LIMITED).—The statutory return of the above-named Company, made up to the 18th July, 1890, was filed on the 15th February, 1892. The Company was registered on the 6th March, 1890, with a capital of £30,000 in £10 shares, to acquire and work certain patents, particulars of which were not given. The patents and rights to be acquired to be fully satisfied by the allotment of 1,000 fully paid-up shares to Francis E. MacMahon or his nominees, and 1,000 fully paid-up shares to Charles H. Ashley or his nominees. The first annual return of the same Company, made up to January 14, 1892, was also filed on February 15, 1892. The whole of the shares have been taken up, and 2,000 issued as fully paid. Upon the remaining 1,000 shares £5. 7s. 6d. per share had been called, resulting in the payment of £4,943. 15s., and leaving £431. 5s. in arrears. The principal subscribers are Charles H. Ashley, of Thirsk Lodge, Hornsey-lane, Highgate, London, N. (1,005), and Edwin Williams, of 3, Finsbury-circus, London, E.C. (721). Francis E. MacMahon, who, in the preceding return, held 450 shares, has sold all his shares in the Company. Registered office: 24, Great Windmill-street, Piccadilly, London, W.

MAQUAY SYNDICATE (LIMITED).—The annual return of the above-named Company, made up to the 25th December, 1891, was filed on the 30th December following. The Company was registered on the 28th September, 1889, with a capital of £12,000 in £100 shares, to purchase and acquire or to enter into arrangements for the option of purchasing and acquiring the benefit of the inventions for an improved voltaic battery, for improved means for feeding electric batteries, and for removing the plates therefrom, and for a miners' lamp respectively, protected by letters patent, No. 15,040 of 1885, No. 990 of 1887, and No. 14,932 of 1888, to test and work the said patents, and to carry on the business of electricians, mechanical and electrical engineers, suppliers of electricity and manufacturers of electrical apparatus. At the time of making up, 92 shares had been taken up, of which 60 had been issued as fully paid. The full amount has been called on 29 of the remainder, resulting in the payment of £2,550 and leaving £350 in arrears. The principal shareholders are:—Sir Redvers H. Buller, K.C.B. (10 £100 shares); Sir Edward R. Sullivan, Bart. (51); W. H. Gramshaw, of the Stock Exchange, E.C. (15); and Samuel W. Maquay (9). Registered office: 9, Frith-street, Soho-square, London, W.

ST. JAMES' AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—The fourth annual return of the above named Company, made up to February 9, 1892, was filed on February 18th following. The Company was registered on March 2, 1888, with a capital of £100,000, divided into 19,980 ordinary shares of £5 each, and 100 founders' shares of £1 each. The Company, however, passed on March 2, 1891, and confirmed on March 20, 1891, special resolutions by which the capital was raised to £200,000 by the creation of 20,000 Seven per Cent. Preference Shares of £5 each, and new Articles of Association were adopted. At the time of making up (February 9, 1892), 18,680 ordinary, the 20,000 Seven per Cent. Preference, and the 100 founders' shares were taken up, £5 per share called on the ordinary and preference, and £1 called on each of the founders' shares, and all calls paid, resulting in the total payment of £193,500. Registered office: Mason's-yard, Duke-street, St. James's, London, S.W.

MINING AND GENERAL ELECTRIC LAMP COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 27, 1892, was filed on February 2, 1892. The Company was registered on November 24, 1888, with a capital of £100,000 in £1 shares, to acquire certain patents relating to the production, supply, or utilisation of electricity or electrical currents, from the New Portable Electric Lamp and Power Syndicate Company (Limited), and to carry on the business of manufacturers of lamps of all kinds and of apparatus connected with the manufacture, consumption, and supply of electricity. An agreement made March 29, 1889, with J. H. Hays and B. Nicholson, the liquidators of the New Portable Electric Lamp and Power Syndicate Company (Limited), fixed the purchase consideration at £80,000 to be satisfied by the payment of £17,695 in cash, £20,000 in fully paid-up ordinary shares, and the remaining £42,305 in cash or fully paid-up shares at the option of this Company; and it was also agreed that 8,190 shares (in addition to the above 20,000) should be issued to the nominees of the New Portable Electric Lamp and Power Syndicate Company (Limited). An agreement made on March 28, 1890, between the same parties, determined that the balance of the above purchase consideration (£34,115) should be fully satisfied by the allotment of 34,115 ordinary fully paid up shares to the nominees of the New Portable Electric Lamp Company. At the time of making up (January 27, 1892), 91,500 out of the total of 100,000 shares, had been taken up, of which 62,305 had been issued as paid in accordance with the above agreements. Upon the remaining 29,195, the full amounts had been called and paid. The principal subscribers are Mrs. T. C. Baring (20,000 shares), Daniel de Castro (2,000), Henry Hoare (10,564), Nevil Maskelyne, M.P. (11,064), B. Nicholson (7,346). Registered office: 11, Abchurch-lane, London, E.C.

MORECAMBE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The statutory return of the above-named Company, made up to November 30, 1891, was filed on December 9th following. The Company was registered on July 27, 1891, with a capital of £15,000, divided into 14,950 ordinary and 50 founders' shares of £1 each, to acquire the rights and powers of Thomas Reginald Andrews and Thomas Preece, the undertakers of the Morecambe Electric Light and Power Order of 1890, of and in the undertaking authorised by that order and to carry on the business of electricians, mechanical and electrical engineers, suppliers of electricity and manufacturers of and workers and dealers in electricity, electric motive power and electric light. At the time of making up, 32 founders' and 2,136 ordinary shares were taken up, of which 360 ordinary shares were issued to Messrs. Andrews and Preece (Limited), electrical engineers, as fully paid. Upon the founders' shares, the full amount has been called, and upon the remaining 1,776 ordinary shares, 4s. per share has been called, resulting in the payment of £339 15s. 0d., and leaving £47 9s. 0d. in arrears. The majority of the shares are taken up by the inhabitants of Morecambe and Bradford. Registered office: 18, The Crescent, Morecambe, Lancs.

MULHOLLAND, MAUGHAM AND CO. (LIMITED).—The first annual return of the above-named Company, made up to November 5, 1891, was filed on the following day. The Company was registered on July 29, 1890, with a capital of £5,000, divided into 120 founders' and 380 ordinary shares, of £10 each, to acquire the business carried on by R. M. L. Mulholland and B. Maugham, at Ferryhill, Durham, and to carry on the business of mechanical and electrical engineers, manufacturers and dealers in all kinds of apparatus required for or capable of being used in connection with electrical engineering, and in particular to construct, lay down, establish, fix and carry out all necessary cables and other works for such purposes. At the time of making-up, 120 founders' and 107 ordinary shares had been taken up. Upon the founders' the full amounts per share have been called, while upon the ordinary shares £5 per share has been called and paid, resulting in the payment of £1,735. Registered office: West Cornforth, R.S.O., Ferryhill, Durham.

MUTUAL TELEPHONE COMPANY (LIMITED).—The first annual return of the above-named Company, made up to January 14, 1892, was filed on February 19th. The Company was registered on February 4, 1892, with a capital of £100,000, in £10 shares. By a resolution of the Company in general meeting, held on July 21, 1890, it was resolved to increase the capital to £350,000 by the creation of 25,000 new shares of £10 each. At the time of making-up (January 14, 1892), 4,135 shares had been taken up, a call of £8 per share made, and £31,750 paid, leaving £1,330 unpaid. Most of the shareholders reside in Manchester and district. Registered office: 10, Tokenhouse-yard, London, E.C.

CITY NOTES, &c.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—The Stock Exchange Committee have ordered the 5,004 additional preference shares, Nos. 69,997 to 75,000, to be quoted in the Official List.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended February 21st were £872, as against £718 in the corresponding period of last year, showing an increase of £154. The total receipts to date, from January 1st, 1892, are £6,227, against £5,479, an increase of £748.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The Board has, upon the accounts for the half-year ended December 31st being submitted, decided, subject to audit, to recommend the payment of dividends at the rate of 10 per cent. per annum on the Preference shares, and at the rate of 4 per cent. (free of income-tax) on the ordinary shares, making with the previous half-year's dividend a total distribution of 4½ per cent. for the year on the ordinary.

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HALIFAX AND BERMUDAS CABLE COMPANY (LIMITED).—The Stock Exchange Committee appointed yesterday (Thursday) as the special settling day in the £120,000 Four and a-Half per Cent. First Mortgage Debentures of this Company.

ST. JAMES' AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—The Stock Exchange Committee have ordered the 10,000 additional preference shares, Nos. 30,081 to 40,080, to be quoted in the Official List.

SANITAS COMPANY (LIMITED).—Mr. F. H. L. R. Moll presided on Tuesday last at the fifteenth ordinary general meeting of the shareholders of the Sanitas Company, and announced a dividend of 10 per cent. for the past year. In the course of his remarks, the Chairman congratulated the shareholders on the great increase in the use of the Company's preparations, and insisted upon the value of Sanitas as a means of preventing the spread of epidemics in large establishments, where considerable numbers of *employés* are working together. Mr. Moll was subsequently re elected a Director of the Company, on the motion of Mr. Kingzett.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED). Notice is given that the transfer books of this Company will be closed from February 22nd to March 1st, both days inclusive, preparatory to the payment of dividend.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The Stock Exchange Committee have appointed this day (Friday) as a special settling day in the £80,000 Five per Cent. Debentures (1917) of this Company, and have ordered the debentures to be quoted in the Official List.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Feb. 17.	Price Wednesday, Feb. 24.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Feb. 24.	
						£ s. d.		Highest.	Lowest.
			TELEGRAPHS.						
£1,300,980	Stock	16/0	Anglo-American ..... xd	49 50	49 50	5 5 0	Jan., Apr., July, Oct	49½	49¼
£2,849,510	Stock	3 3/0	Do. Preferred ..... xd	88 89	88 89	5 18 0	" "	89	88
£2,849,510	Stock	5/0	Do. Deferred	12 12¼	11¾ 12⅛	..	" "	12 1/16	12
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10⅞ 11¼	10¾ 11⅛	7 2 8	Mar., June, Oct., Dec	11⅛	10 15/16
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 5	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	153 157	153 157	4 9 2	Jan., Apr., July, Oct.	155½	155
16,000	10	8/0	Cuba Submarine ..... xd	10 11	10 11	7 5 6	February and August	10 1/16	10 1/16
6,000	10	10%	Do. Preference 10% ..... xd	16 17	16 17	5 17 8	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3⅛ 3⅜	3⅛ 3⅜	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	8⅝ 9⅛	8¼ 9⅛	5 5 3	" "	9 1/16	..
60,710	20	3/6	Direct United States	11 11⅛	11 11⅛	6 5 0	Jan., Apr., July, Oct	11 1/16	11⅛
400,000	10	2/6	Eastern	14⅛ 14⅜	14⅛ 14⅜	4 7 5	" "	14⅜	14⅛
70,000	10	6%	Do. 6 per Cent. Preference	15 15⅛	15 15⅛	3 17 5	" "	15⅛	14 15/16
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.....	107 110	107 110	3 12 9	May and November	109½	108½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	105 108	105 109	4 11 9	February & August	106	..
250,000	10	2/6	Eastern Extension	15 15⅛	14⅞ 15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	14 13/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	105 108	106 109	3 13 5	February & August	108½	106½
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb..1900 ..	101 104	101 104	4 16 2	" "	102½	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)....	99 102	99 102	3 18 5	February & August	..	..
180,227	10	1/6	Globe Telegraph and Trust	9⅞ 10⅛	9⅞ 10⅛	5 6 2	Jan., Apr., July, Oct.	10 1/16	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15⅛	14⅞ 15⅛	3 19 10	" "	15⅛	14⅞
150,000	10	5/0	Great Northern	19 19½	18¾ 19¼	4 8 4	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106 109	106 109	4 11 9	March & September	108	107
17,000	25	12/6	Indo-European	41 43	41 43	5 16 3	May and November	..	..
38,848	10	4/0	London Platino-Brazilian	6 7	6 7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	7⅛ 8	7⅛ 8	5 3 2	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	115 120	115 120	5 0 0	" "	117½	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	101 104	101 104	4 6 7	March & September	103	..
30,000	10	2/0	West Coast of America	4 5	4 5	..	January and July ..	4⅜	4⅜
£150,000	100	8%	Do. Debentures 8% 1902	101 105	102 106	7 10 11	June and December	101½	..
88,321	10	1/0	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	..	" "	1⅜	1 1/16
34,563	10	6%	Do. 6 per Cent. 1st Preference.....	9⅛ 10	9⅛ 10⅛	5 17 1	May and November	10	9⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8⅛ 9⅛	8⅛ 9⅛	6 6 4	" "	..	..
67,007	15	6/0	Western and Brazilian	10⅛ 10⅝	10⅛ 10⅝	7 2 10	" "	10⅛	10⅛
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6½ 6⅞	6½ 6⅞	5 7 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4 4½	4 4½	..	" "	4 1/16	4 1/16
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	101 104	101 104	5 15 5	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910..	101 104	101 104	5 15 5	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£178,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,350	14/0	4·094d.	Consolidated Telephone Const. & Maintenance. ..	⅜ ½	⅜ ½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	½ ⅝	½ ⅝	6 8 11	Yearly	..	..
438,984	5	2/6	National	4⅛ 4⅜	4⅛ 4⅜	6 17 2	June and December	4 1/16	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13½ 13⅞	13 13⅜	4 8 11	" "	13 1/16	13⅜
15,000	10	6%	Do 6% Cumulative 2nd Pref.	11⅝ 12⅛	11⅝ 12⅛	4 16 0	" "	12	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	104 107	104 107	4 4 1	January and July ..	105⅞	106⅜
58,000	5	1/0	United River Plate	1 2	1 2	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock.....	80 90	80 90	5 11 1	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
39,152	£10	..	City of London Electric Lighting (£6 paid)	6⅛ 6⅜	6⅛ 6⅜	..	—	6 1/16	6⅛
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	.. ..	5⅛ 5⅜	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.	5⅜ 6	5⅛ 6⅛	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5⅛ 6	5⅛ 6⅛	..	January and July ..	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2⅜ 2⅝	2⅜ 2⅝	..	March	..	..
10,000	£5	3½%	Do. (fully paid)	4⅜ 5	4⅜ 5	..	March	..	..
111,000	5	..	London Electric Supply	1 1⅛	1 1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8⅛ 9	8⅛ 8⅝	..	..	8⅜	8 1/16
6,318	10	..	Notting Hill Electric Lighting (fully paid).....	5 6	4⅛ 5⅛	—	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8⅛ 8⅝	8⅛ 8⅝	—	..	8⅛	8⅛
7,900	£5	7%	Do. 7% Preference	7⅛ 7⅜	7⅛ 7⅜	..	..	7⅛	..
42,853	5	..	Westminster Electric Supply (fully paid)	5⅞ 6⅛	5⅞ 6⅛	..	..	6⅛	5 15/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1 8	Brush Electrical Engineering.....	3⅛ 3⅜	3⅛ 3⅜	..	..	3⅜	3⅛
69,996	2	6%	Do. 6 per Cent. Preference	2 2⅛	2 2⅛	5 7 7	..	2⅛	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5⅛ 6	5⅛ 6	5 16 8	January and July ..	5 1/16	..
17,180	5	17½	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	5⅞ 6⅛	5⅞ 6	..	—	5⅞	5⅞
70,000	2	10/0	Elmore's Patent Copper Depositing	3 3⅛	3 3⅛	..	—	3 1/16	3⅛
20,000	5	..	Fowler-Waring Cables (£4 paid).....	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works ..	21½ 22½	21 22	4 10 11	February & August	22½	21½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 106	103 106	4 4 6	March & September	104½	..
11,334	£10	6/1	International Okonite Limited Ordinary	3½ 4½	3½ 4½	..	..	..	..
11,334	£10	8/0	Do. Preference	8 9	8 9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	7/8 15/16	4 7/16 4 9/16	..	..	..	..
75,949	5	5/7½	Swan United (£3. 10s. paid)	3¾ 4¼	4 4⅛	8 11 10	May and November	4½	4
30,250	12	12/0	Telegraph Construction and Maintenance	44 46	45 47	5 2 7	March and July.....	46½	45½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100 108	101 104	4 16 2	January and July .	103½	103
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	1⅜ 1⅝	7/8 1⅛	5 15 9	..	..	..
—	£5	8%	Do. Preference (fully paid).....	3½ 3¾	3 3⅛	10 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,550	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	—	—	..	..
50,000	£10	—	City and South London Railway	2⅛ 3⅛	2⅛ 3⅛	..	—	..	..

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NOTES.

We regret to learn that the Sunbeam Lamp Company has been compelled by the Edison-Swan Company to suspend their manufacturing business. Their high candle-power lamps possessed several advantages, and it is not surprising that the Edison-Swan Company has taken decided action; indeed, it is somewhat of a mystery why nothing was done before. We are given to understand that the ball was opened a few months ago by warnings given to customers of the Sunbeam Company. This *modus operandi* has the sanction of long usage, but is none the less injurious to the best interests of the electrical industry at large.

It is sincerely to be hoped that the system of Pioneer Companies will not bring electrical enterprise into such disrepute as the parent and sub-company systems at one time succeeded in doing. The financial manœuvres which took place at the time of the promotion of the City lighting yielded the original speculators a sum of money, called a bonus, amounting to 50 per cent. on their investments; although the starting of that enterprise is so far from being an engineering success that the contractors have had to plead for extension of time, and appear to have met with difficulties which were unforeseen, at all events by themselves. The certainty of a demand for the electric light in the City, and the absolute monopoly of the undertaking—for a failure to execute the contract was not dreamed of—were two sources of strength to the "pioneers." Following on this "success," the Central London Electric Railway appears now to have fallen into the hands of similar financiers.

The New Telephone Company, originally started with the object of providing a transmitter which should be free from the great monopoly, threatened at one time to enter the field with a subscribers' service. The transmitter was declared to be an infringement, and was crushed; and the New Telephone Company ceased to do business, but not before it had secured a twenty years' licence from the Postmaster-General. The New Telephone Company is, we regret to hear, also to be pioneered. The term "pioneer" is absurd in the face of some fifty thousand telephone subscribers in the country and in London. The New Company has not, nor can it hope to have, any monopoly whatever, but it proposes to compete against a well-established system. The New Company starts with a licence, a Bill before Parliament which is opposed by the Post-office, and, it is suggested, the privilege of running its wires in the casings which are now being laid by the City of London Electric Lighting Company. The one essential object of any telephone system is to enable any one subscriber to be placed in communication with any other. No suggestion has yet been made of any plan for connecting subscribers of the new Company with those of the old, unless indeed in our leading article last week, and that appears to be quite impracticable. All the present subscribers want a better service, a large majority wants a cheaper one. The National Telephone Company is really trying to amend the service; and it seems much more likely to succeed in pleasing its subscribers, or in being taken over by the Post-office, than to be swamped by a competing concern.

The great use of diagrams to represent in a clear, brief, and speedy way the essential parts of apparatus referred to by the author of a Paper is sufficiently obvious; and now that alternate and multiphase currents have so increased the complexity of electrical methods of distribution, it is of as much importance for the writer of an article to describe his work by means of a well-arranged diagram as by clearly expressed sentences. The meaning of a diagram can be very rapidly grasped if the signs used to denote currents, electromotive forces, magnetic poles, &c., are such as one is familiar with; and it is thus desirable that a uniform system of signs should be adopted. M. Hospitalier, in his excellent work on Electrical Energy, has consistently used throughout his book some very good diagram signs; and Professor S. P. Thompson, on Friday last at the Physical Society, made a number of useful suggestions in this direction. We are compelled to hold over a description of these owing to pressure on our space.

While it may be impossible to get authors to adopt the same symbols in the analytical expressions occurring in their writings, it will be generally admitted that such uniformity would much diminish the length of time and the amount of thought needed by the average reader to grasp the meaning conveyed. But although this uniformity may be impracticable for algebraic symbols, it does not seem so much so for diagram signs, the importance of which is even greater, since they appeal not only to those who read the algebra but to those who skip it.

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In our issue of December 25, 1891, we referred to a violent dispute which was said to have arisen between Prof. Elisha Gray and the American Institute of Electrical Engineers, with regard to the proposed International Electrical Congress at Chicago; a Congress which we ventured to opine would prove the most promising international feature of the Exhibition if conducted on sound lines. Subsequently in our issue of January 22nd, our New York correspondent stated that the unfortunate difficulty was at an end, "Prof. Gray having seen the advisability of acceding to the propositions of the Institute." We now hear on excellent authority that this statement by no means represents the facts. "The electrical journals here have quite persistently represented a conflict between the American Institute of Electrical Engineers and the local Committee on World's Electrical Congress, appointed by the Exposition authorities. Prof. Gray says that from the first the officers of the Institute of Electrical Engineers have entirely disclaimed any opposition or feeling on the subject. They have met Prof. Gray with great cordiality, and with a disposition to co-operate harmoniously with the Committee on the Congress. The Committee of the Institute has done everything asked by Prof. Gray cheerfully and without hesitation." These statements are borne out by the following resolution passed at a meeting of the Council of the Institute:—

Resolved, That the American Institute of Electrical Engineers, having already taken action during the past three years, by correspondence and otherwise, towards the holding of an International Electrical Congress in connection with the Columbian World's Fair, hereby expresses its desire and intention to co-operate, by all means in its power, with the World's Congress Auxiliary of the World's Columbian Exposition, through its Electrical Congress Committee, in furthering the gathering of such a Congress at Chicago in 1893, and in making it a successful and worthy representation of the best electrical science and practice in all parts of the world.

Our leading magneticians hold that all substances are magnetic under appropriate conditions. That being so, would it not be worth while to inquire whether the requisite concatenation of circumstances did not obtain at the last meeting of the Institution of Electrical Engineers? Speaker after speaker arose, gazed wistfully at the brilliant assembly, and then little by little was drawn towards the blackboard, like iron dust to a magnet, and before long was flattened against its polar surface, there to remain until dissipated by the rising temperature of the audience and presidential pressure. All felt this mysterious influence; the μ's of the professor and the engineer were sensibly the same. Nothing indeed but the "reluctance" of the assembled members prevented even the rubber and fibre champions from doing battle on the board by the aid of powerful operators and convenient approximations.

The algebraic symbols were more than usually microscopic, the surface of the board was abnormally bad, and 90 per cent. of the tangled expressions were invisible amidst the encircling gloom cast by ponderous overhanging diagrams. That *rara avis* a "typical higher harmonic" was at one time on view, and we were desired to inspect it; our ocular organs not, however, being sensitive to Hertz oscillations, we were unable to see through the head of one professor and the body of another; so that the intellectual treat was entirely missed by us. Exactly what we lost, we don't quite know; but we feel sure it was something good.

In view of the renewal of these mathematico-gladiatorial displays we would urge every member of the Institution to arm himself with a pair of Sam Weller's double-million magnifying glasses; unless the formulizers will take pity and provide a sufficient number of lithographed sheets of their equations, though perhaps they really concoct them on the spot. This we doubt.

Blackpool.—The Electric Lighting Committee have decided to recommend the Council to extend the electric lighting.

Personal.—The Council of the Gas Institute has, we understand, nominated Mr. Denny Lane, of the Cork Gas Consumers' Company, as president, in succession to Mr. Valon.

McGill University.—Prof. Carus-Wilson, the newly-appointed instructor in electrical engineering at this University, is at present engaged in re-arranging and extending the course.

Birds of a Feather.—The President of the Electropathic and Zander Institute complains that a man is going about London "committing a most impudent fraud on the public."

St. Pancras Vestry.—This vestry has given notice of the withdrawal of the deposited Bill, under which powers were sought to borrow £360,000 for the electric lighting of the whole of the parish.

Lord Kelvin.—Lord Kelvin (Sir W. Thomson) took the oath and his seat, in the House of Lords, on his elevation to the peerage, on Thursday last. He was introduced by Lord Rayleigh and Lord Sandford.

British Association.—The Edinburgh meeting of the British Association will commence on Wednesday, August 3rd. On Monday evening, August 8th, a discourse on magnetic induction will be delivered by Prof. J. A. Ewing, F.R.S.

Indian Telegraphs.—The telegraph has been extended from Bhamo to Nampoung post on the Chinese frontier. There is now a gap of only 65 miles between the terminus of the English wire and the Chinese telegraph station at Momein.

Obituary.—The death is announced of Sir John Coode, K.C.M.G. Sir John Coode was born in 1816, and began his career under the eminent engineer Rendell. He was President of the Institution of Civil Engineers in the years 1889 and 1890.

Inland Telegraph Money Orders.—On Tuesday last this system, which has hitherto been in operation only at head and branch offices, was extended to all post offices in the United Kingdom at which telegraph and money order business is transacted.

Worcester.—At the meeting of the Watch Committee last week it was reported that fifteen tenders had been received for the supply of electric light under the provisions of the Council's Order; and Mr. W. H. Preece was engaged to advise the Council on the tenders.

Electric Tramways for Madras.—It is stated that Messrs. William Hutchinson and Co., of London, intend to bring out a company for the construction of electric tramways in Madras. The Madras Government has authorised the project. The overhead conductor system will probably be adopted.

Electric Lighting at the Mansion House.—In consequence of an important engagement the Lord Mayor and Lady Mayoress were unable to be present at the proposed electrical private view at the Mansion House, announced for Tuesday last; and, therefore, it was postponed until Monday, March 7th.

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Institution of Civil Engineers.—At the ordinary meeting of this Institution on Tuesday, March 1st, it was announced that the monthly ballot had resulted in the election of three honorary members, viz.:—Dr. Werner von Siemens, Field-Marshal Sir John Lintorn Simmons, and Sir George Gabriel Stokes, Bart.

Old Students' Association.—The Paper on "The Behaviour of Insulating Materials under the Action of High Potential Differences," which will be read on Friday next before this Association by Messrs. H. B. and W. Fox Bourne, will be illustrated by large scale experiments with a transformer giving 50,000 volts.

The House to House Electric Supply Company.—We are informed that the words quoted from Mr. Gay's letter in our last issue, "The total period during which this portion of the lights were out averages about one hour," means that the longest period during which any of the lights were out was under two hours. A clear statement of the time of the break-down and the time at which the engines were re-started would have saved us from referring to other information which appears to have been inaccurate.

A Cold Galvanising Process—The usual process of coating iron or steel articles by steeping them in molten zinc is somewhat wasteful of zinc, and has the disadvantage of reducing the strength of wires. The London Metallurgical Company has recently introduced a cold process, for which they claim the following advantages: a better protection to the iron for an equal thickness, and a better adhesion, for the same cost. Mr. Arnold Philip, Assoc. Royal School of Mines, F.I.C., F.C.S., has reported favourably on the process.

Patent Specifications.—A uniform price of 8d. will in future be charged for all printed specifications. Over 10,000 of these are issued every year, and up to the present time the price of each varied from 3s. to 4d. Henceforth any specification in stock can be obtained from the Patent Office at 8d.; and arrangements have been made with the Postmaster-General by which postal requests in the form of a postcard, price 8d., will be on sale at each post-office, so that any one knowing the number and year of a particular patent may, on filling in the blanks on the card, have a copy of the specification delivered at his address by return of post, without further expense or correspondence.

Antwerp.—At its meeting on Friday last the Conseil Communal adopted the electric lighting scheme of MM. Moris and Van Rysselberghe. These gentlemen will have to deposit immediately as a security the sum of £20,000, and a second similar sum within six months. They are to establish an hydraulic network for the supply of water at 150lb. pressure, and may also run underground electric mains. The town may within four years demand an electric supply for street lighting, the current to be paid for on the sliding scale plan. At the end of 25 years the current will be supplied to the public lamps gratuitously, and the concessionnaires will be freed from any municipal tax, and allowed to make use of overhead wires.

The Telephone in Parliament.—On Thursday, last week, Dr. Cameron asked the Postmaster-General whether he was yet in a position to announce the decision of his department on a question stated by his predecessor to have been under consideration at the beginning of last Session—the granting of licences for telephone exchanges to applicants proposing to introduce loud-speaking and other improved forms of telephone, which had become available through the expiration of the principal telephone patents in July last. In reply the Postmaster-General stated that the subject was part of one of a much wider scope which had occupied his attention ever since he entered upon his present office, and which was being considered by Her Majesty's Government; but, speaking generally, with regard to the grant of additional licences, each application must be considered upon its individual merits.

The French Electrical Tariff.—At the last meeting of the Syndicat Professionel des Industries Electriques, which played such an important part in securing the imposition of protective duties on electrical goods entering France, it was stated that the Government had originally entirely forgotten to tax anything electrical except arc-light carbons. The efforts of the Syndicat met with varying degrees of success. A 20 per cent. *ad valorem* duty was asked for in the case of incandescent lamps, but not more than 8·5 per cent. was obtained. On the other hand, only a 20 per cent. duty on arc-light carbons was asked for; but duties ranging from 15 per cent. to 22 per cent. have been imposed in the general tariff; and similarly in the case of dynamos duties ranging from 5 per cent. to 20 per cent. have been imposed, while 10 per cent. only was asked for.

An Ingenious Electric Automatic Machine.—An ingenious automatic machine has been established near the letter-box at Charing-cross for the collection of letters to be forwarded by the Post Office Express Service. It is in electrical connection with the postal telegraph office opposite the station. By dropping a penny into the slot and pulling out the slide, a brown-coloured envelope is delivered. This envelope contains another envelope and a card. The communication is intended to be written on the card, which is then enclosed in the white envelope, and this, with the fees for delivery, which have been fixed at threepence per mile, is re enclosed in the outer envelope and deposited in the box behind the flap which bears the printed instructions. The act of withdrawing the slide sends the call signal to the telegraph office, and a messenger is at once despatched to collect the special letters.

The Telephone Companies' Bills.—Mr. R. G. Webster will move, after the Second Reading of the Telephone Companies Bills, that they shall be referred to a Hybrid Committee, with a view to the consideration of the advisability of introducing provisions which will put the telephone companies generally on a similar footing to that on which the gas and water companies are placed by existing Acts.——The Bills will meet with strong opposition before reaching the Committee stage. In the case of both Bills, Mr. Kimber has undertaken to move their rejection on second reading; and in the case of the New Telephone Company's Bill, Sir Albert Rollit has also given notice to move its rejection. Petitions against the National Company's Bill have been presented by more than 170 Local Authorities, by nearly 50 Gas, Water, Railway, and Electric Supply Companies, and by some 10 property owners. Against the New Telephone Company's Bill 60 Local Authorities, 20 Companies, and 8 property owners have petitioned.

Cable and Land Line Interruptions and Repairs:

	Date of interruption.		Date of repair.
	1891.		1891.
St. Thomas-St. Kitts Cable	Oct. 13		Oct. 23.
Brest-St. Pierre Cable (Anglo-American)	Nov. 19		*
	1892.		1892.
Perim-Asab Cable	Jan. 5		*
Para-Maranham Cable	„ 18		*
San Thomé-St. Paul de Loanda Cable	„ 22		Feb. 19.
Zanzibar-Mombassa Cable	„ 25		*
D'El-Arich Line	„ 30		Jan. 31.
Buenaventura-Sta Elena Cable	Feb. 12		Feb. 20.
Communication with Constantinople	„ 15		„ 16.
Brest-St.-Pierre Cable (Cie. Française)	„ 13		March 1.
Saigon-Bangkok Cable	„ 17		*
Saigon-Singapore Cable	„ 18		*

* Not yet repaired.

Electric Insurance.—"It is reported," says *Industries*, "that during the Electrical Exhibition the Crystal Palace insurance rates have been raised some 30 per cent. . . The harm done to the electric light industry by this ill-advised action of the insurance companies is incalculable. It is as if they said that electric lighting is dangerous, whereas the whole object of the Exhibition is to show that electric lighting is now practically perfect. . . There are two ways out of difficulties of this sort. One is not to insure at such onerous rates, but to take the small risk without insuring at all; another is to insure elsewhere. There is now a splendid opportunity for starting an electrical insurance company." The idea of an electrical insurance company is, of course, no new one, but previous preliminary attempts to form such a company did not meet with much support in financial circles. But perhaps the time has now come for a renewed endeavour.

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The London Telephone Service.—"The real secret of the business," says the *Economist*, "is that the National Telephone Company has to pay dividends upon a capital that was watered to the extent of over 50 per cent. when the amalgamation with the United, Lancashire and Cheshire Companies took place in 1889. . . . Since the amalgamation the dividends have been modestly restricted to 6 per cent.; but 6 per cent. on the present nominal capital means very much more on the actual amount invested. To the United Telephone shareholders, in fact, it means 15 per cent. . . . With such a showing as this it is ridiculous to put forward the plea that the Company works under such peculiarly disadvantageous conditions in the metropolis that the present excessive charge for the service is justified, and that a reduction in the charge can only be made practicable if the Company is granted the statutory powers asked for in the Bill now before Parliament. In our view these additional powers should be withheld, at all events until the National Telephone Company has shown itself willing to deal more fairly by its metropolitan customers."

Electric Traction on the West Metropolitan Tramway System.—At the meeting of the West Metropolitan Tramway Company on Monday last, the Chairman remarked that he had once stated that two things were requisite to make the Company a success; the first was a double line, and the second was electric traction. They had commenced the double line, and as to the adoption of electricity, they had at last got the consent of the Local Authorities. The local authorities would not, however, either permit overhead wires or a "slot" in the road. He would be very glad indeed if the Lineff system could be adopted upon their line, but he would not risk a farthing of the shareholders' money in any experiment. If the Lineff Company liked to come forward and carry on the traffic at a less cost than by horse-power, they could. If anyone would only do the work for 4½d. per mile on the West Metropolitan system, he would hand the whole line over to them to work. The West Metropolitan Company could not afford to pay 9d. a mile; but if a company would do it for less it would be a different thing.

The Value of Useless Studies.—The following letter from Prof. G. F. Fitzgerald, which appeared in last week's *Nature*, will be read with interest:—

"It is rather surprising that Prof. Ayrton should indulge in covert sneers at Universities for devoting themselves to useless studies. It certainly ill becomes one whose life is bound up with electrical science, which is of such recent growth that nobody can pretend to forget how it owes its origin to those who studied it while useless. If Universities do not study useless subjects, who will? Once a subject becomes useful, it may very well be left to schools and technical colleges, to patent-mongers, and the trade. Mr. Bury is, on the other hand, mistaken in two respects. That a subject is useless is hardly worth considering as a recommendation for its being made *compulsory* on students. There are too many useless subjects for that. The great objection to compulsory Greek is that it is the principal stumbling-stone in the way of any literature being studied by ordinary University students. The Bible produced very little effect until it was read in translations; and the danger of a pagan revival, if ancient literature were studied without the obstruction of difficult languages, is the best reason for insisting on these languages in a Christian University. The second mistake of Mr. Bury is that it is any part of the business of a University to *teach*. Universities should certainly give facilities for students to *learn*. It is the business of the students to learn. If they are so ill prepared that they have not acquired the art of learning, they should go to a college or school or private teachers, and get taught; for teaching is the business of these institutions and persons. The business of Universities is to advance culture and knowledge, and to afford students an opportunity of learning how to do this. Prof. Ayrton, by omission, rather than by commission, seems utterly unable to appreciate the value of literature for its own sake. How can all this fierce toil he extols so justly advance a lot of savages?"

The Electric Railway Bills.—There is every appearance of considerable opposition to the several local railways which are being promoted in London. The petitioners praying to be heard against the Baker-street and Waterloo Railway include the trustees of the Constitutional Club, the National Liberal Club Buildings Company, the Gordon Hotels, the trustees of the County Fire Office and Provident Life Office, the Hotel Victoria, the vestry of the parish of St. Marylebone, the Society for Promoting Christian Knowledge, and Viscount Portman. Against the Central London Railway Extension Bill the Corporation of London and the London and North-Western Railway Company have presented petitions. Among the opponents praying to be heard against the City and South London Railway Extension Bill are the vestry of St. Mary, Islington, the Ecclesiastical Commissioners, the authorities of the Orphan Working School at Haverstock Hill, the trustees of the Stockwell Orphanage, and the Corporation of London. The Hampstead, St. Pancras, and Charing-cross Railway Bill is petitioned against by Messrs. Maple and Co., the Great Northern, London and North-Western, and Midland Railway companies, and the vestry of St. Marylebone. Mr. John Walter and the Corporation of London petition to be heard against the Waterloo and City Railway.—In the House of Commons on Tuesday evening Mr. Whitmore moved the appointment of a joint committee to consider the best method of dealing with the electric and cable railway schemes. The resolution was carried without opposition.

Aluminium Soldering.—The following methods of soldering aluminium are recommended by the Neuhausen Company. For sheet aluminium an iron-tin solder may be used with a flux composed of resin, neutral chloride of zinc, and grease. The metal should not be cleaned or scraped unless it is absolutely necessary to do so, in which case alcohol or essence of turpentine should be used for the purpose. For 5 per cent. aluminium bronze tin solder may be employed, but this is not possible with the 10 per cent. alloy, in which case the company recommends a preliminary copper plating. If it is difficult to dip the ends to be plated directly into the solution, pieces of blotting paper soaked in a solution of $CuSO_4$ may be laid on them, and a current passed. The flux mentioned above may be used. Another solder which is recommended is one consisting of copper 56 parts, zinc 46 parts, and tin 2 parts, applied with borax. Some tests made at Neuhausen showed that with these solders plates of aluminium soldered together edge to edge required a tractive effort of from 16½ to 18 tons per square inch to pull them asunder; if the edges overlapped 22¼ tons per square inch were required. Pieces of cast aluminium bronze, if placed in sand moulds, can be joined together autogenously by running in some of the molten metal. If this operation is properly carried out the joint is indistinguishable from the rest of the casting. Thin cylinders of aluminium are made in this way by bending the sheets round end to end, and soldering with molten aluminium.

Sunspots and Magnetic Disturbances.—In a recent communication to the *Comptes Rendus* (Vol. CXIV., No. 8) entitled "Note sur une tache solaire observée à l'Observatoire de Meudon du 5 au 17 Février courant," M. Janssen stated that with regard to the question of the relation between the phenomena of sunspots and terrestrial magnetic disturbances, he saw nothing in the facts hitherto brought to light to warrant the hypothesis of there being any correlation between them. However, as nothing ought to be rejected *a priori*, and as the study of the question could not but be advantageous to the progress of science, he would like to see meteorological and magnetic observatories multiplied on the surface of the earth, and particularly in the Southern hemisphere, so as to enable us to extricate, from amongst the magnetic and electric manifestations those which had a general and simultaneous character for an entire hemisphere; for it was evident that it was only phenomena of that order which could be attributed to solar action. With this view, M. Janssen would like M. Mascart to inquire of foreign meteorologists if, at the time of the fine aurora observed in America and Europe, and to which must be attributed the great magnetic disturbances recorded, anything of the same kind took place in the Southern hemisphere. Doubtless the Southern hemisphere, being before all things a watery one, auroral phenomena would be less frequent and intense than in our own, and moreover the observatories being further from the auroral regions, observations would be more difficult. Nevertheless, if it were thoroughly ascertained that nothing of the same kind took place at the same time in the Southern hemisphere, we should be in the possession of a fact which would render the theory of solar influence a very improbable one. In any case, M. Janssen was of opinion that it was by means of investigation and verifications of this description that we should succeed in solving the question, as yet so obscure, of the correlation between the accidents on the solar surface and terrestrial magnetic and electric phenomena.

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ELECTROMAGNETIC THEORY.—XXV.

BY OLIVER HEAVISIDE.

(Continued from page 377.)

§ 122. The Hamiltonian vector ∇ occurs in all physical mathematics involving three dimensions, when treated vectorially. It is defined by

$$\nabla = \mathbf{i}\frac{d}{dx} + \mathbf{j}\frac{d}{dy} + \mathbf{k}\frac{d}{dz}, \quad . \quad . \quad . \quad . \quad (119)$$
$$= \mathbf{i}\nabla_1 + \mathbf{j}\nabla_2 + \mathbf{k}\nabla_3,$$

the second form being merely an equivalent one, often more convenient, and easier to set up. We see that the Hamiltonian is a fictitious vector, inasmuch as the tensors of its components are not magnitudes, but are differentiators. As, however, these differentiators are scalar—not scalar magnitudes, but scalar operators, having nothing vectorial about them—the Hamiltonian, in virtue of **i**, **j**, **k**, behaves just like any other vector, provided its differentiating functions are simultaneously attended to. Of course, an operand is always implied, which may be either scalar or vector.

The Hamiltonian has been called Nabla, from its alleged resemblance to an Assyrian harp—presumably, only the frame thereof is meant, without any means of evoking melody. On the other hand, that better known musical instrument, the Triangle, perhaps equally well resembles ∇, and it does not want strings to play upon.

First notice that

$$\mathbf{i}\nabla = \nabla_1, \qquad \mathbf{j}\nabla = \nabla_2, \qquad \mathbf{k}\nabla = \nabla_3, \quad . \quad . \quad (120)$$

and that these are all special cases of the scalar product

$$\mathbf{N}\nabla = \mathrm{N}_1\nabla_1 + \mathrm{N}_2\nabla_2 + \mathrm{N}_3\nabla_3, \quad . \quad : \quad . \quad (121)$$

where **N** is any unit vector. Here $\mathbf{N}\nabla$, or its equivalent Cartesian expansion, means differentiation with respect to length, say s, measured along the axis of **N**, usually denoted by

$$\frac{d}{ds} = l\frac{d}{dx} + m\frac{d}{dy} + n\frac{d}{dz}, \quad . \quad . \quad . \quad . \quad (122)$$

or by similar forms. This operation was termed by Maxwell differentiation with respect to an axis, which we may more conveniently call axial differentiation. We see, therefore, that $\mathbf{N}\nabla$, or the **N** component (scalar) of ∇, is an axial differentiator, the axis being that of **N**. Thus,

$$\mathbf{N}\nabla.\mathrm{P} = \frac{d\mathrm{P}}{ds}, \qquad \mathbf{N}\nabla.\mathbf{A} = \frac{d\mathbf{A}}{ds}, \quad . \quad . \quad (123)$$

P being scalar and **A** vector. Also

$$\mathbf{N}\nabla.\mathbf{AB} = \mathbf{A}.\mathbf{N}\nabla.\mathbf{B} + \mathbf{B}.\mathbf{N}\nabla.\mathbf{A}, \quad . \quad . \quad (124)$$
$$\mathbf{N}\nabla.\mathrm{V}\mathbf{AB} = \mathrm{V}(\mathbf{N}\nabla.\mathbf{A})\mathbf{B} + \mathrm{V}\mathbf{A}.\mathbf{N}\nabla.\mathbf{B}, \quad . \quad (125)$$

and so on, simply because $\mathbf{N}\nabla$ is a differentiator. Expanded in Cartesians, (124) contains the eighteen differential coefficients of the components of **A** and **B** with respect to x, y, and z. The last two equations will also serve to illustrate notation. The dots are merely put in to act as separators, and keep the proper symbols connected. Mere blank spacing would do, but would be troublesome to work. We may, however, use brackets equivalently.

Thus, $\mathbf{A}.\mathbf{N}\nabla.\mathbf{B}$ may be written $\mathbf{A}(\mathbf{N}\nabla)\mathbf{B}$, and this form may be used with advantage if found easier to read. Of course, $\mathbf{N}\nabla$ being scalar, on its insertion between the two members of **AB**, the result remains a scalar product. Similarly, $\mathrm{V}\mathbf{A}.\mathbf{N}\nabla.\mathbf{B}$, arising from $\mathrm{V}\mathbf{AB}$, is still a vector product.

A somewhat more general operator is $\mathbf{v}\nabla$, where **v** is any vector. It is plainly v times the corresponding axial differentiator, or $v.\mathbf{v}_1\nabla$. Thus, expanded,

$$\mathbf{v}\nabla.\mathbf{D} = (v_1\nabla_1 + v_2\nabla_2 + v_3\nabla_3)(\mathbf{i}\mathrm{D}_1 + \mathbf{j}\mathrm{D}_2 + \mathbf{k}\mathrm{D}_3), \quad . \quad (126)$$

which we may separate into **i**, **j**, **k** terms if we like.

When **v** is the velocity of moving matter, $\mathbf{v}\nabla$ comes frequently into use. Let, for example, w denote the measure of some property of the moving matter (here a scalar, but it may equally well be a vector), and, therefore, a function of position and of time. Its rate of change with the time at a *fixed* point in space is dw/dt, and the matter to which this refers is changing. But if we wish to know the rate of time-change of w for the *same* portion of matter, we must go thus. Let $\delta w/\delta t$ denote the result, then

$$\frac{\delta w}{\delta t} = \frac{dw}{dt} + \frac{dw}{dx}\frac{dx}{dt} + \frac{dw}{dy}\frac{dy}{dt} + \frac{dw}{dz}\frac{dz}{dt},$$

by elementary calculus. Or

$$\frac{\delta w}{\delta t} = \frac{dw}{dt} + \mathbf{v}\nabla.w, \quad . \quad . \quad . \quad . \quad (127)$$

where **v** is the velocity of the matter.

This is the equation extensively employed in hydrokinetics. In elastic solid theory the term $\mathbf{v}\nabla.w$ is generally omitted, being often small compared with the first term on the right. But, in special applications, it may happen that any one of the three terms in (127) vanishes. Thus the term on the left side obviously vanishes when w keeps the same in the same matter. If, however, for w we substitute a vector function, say **A**, even though it may not suffer change at first sight in the same matter, yet the rotational part of the motion will alter it by turning it round, so that $\delta\mathbf{A}/\delta t$ will not vanish.

The operator $\delta/\delta t$ is distributive, like d/dt and $\mathbf{v}\nabla$, as exemplified in (124), (125).

§ 123. If the moving matter is so connected that it moves as a rigid body, we have a further development. If we set a rigid body spinning about a fixed axis whose direction is defined by the unit vector $\mathbf{a}_1$, with angular speed a, the speed of any point P in the body equals the product of its perpendicular distance from the axis into the angular speed, and the direction of P's motion is perpendicular to the plane through the axis containing P. That is, a given particle describes a circle round the axis. This is obviously necessitated by the rigid connection of the parts of the body (or detached bodies). The velocity of P is therefore expressed by

$$\mathbf{v} = \mathrm{V}\mathbf{ar}, \quad . \quad . \quad . \quad . \quad . \quad (128)$$

if $\mathbf{a} = a\mathbf{a}_1$, and **r** is the vector to P from any point O on the axis. This is by the definition of a vector product.

Here we may observe a striking advantage possessed by the vectorial method. For (128), obtained by elementary considerations, proves without any more ado that angular velocities about different axes compound like displacements, translational velocities, or forces, or, in short, like *vectors*. Thus, in (128) we see that the velocity of P is the vector product of **a** and **r**. The latter fixes the position of P. The former depends on the spin, its tensor being the angular speed, and its direction that of the axis of spin. Now every vector, as before seen, may be expressed as the sum of others, according to the rule of vector addition. But every vector has its species. Thus, **r** being a vector distance, its components are vector distances. Similarly, **a** being a vector axis of spin with tensor equal to the angular speed, the components of **a**, for instance, the three terms on the right of

$$\mathbf{a} = \mathbf{i}a_1 + \mathbf{j}a_2 + \mathbf{k}a_3,$$

are vectors of the same nature. Therefore any spin may be replaced by other spins about other axes, according to the vector law. Of course the body cannot spin about more than one axis at once, but its motion is the same as if it could and did. This property is notoriously difficult to understand by Cartesian mathematics.

The most general kind of motion the rigid body can possess is obtained by imposing upon the rotational any translational velocity common to all parts. Let **q** be this translational velocity, then, instead of (128),

$$\mathbf{v} = \mathbf{q} + \mathrm{V}\mathbf{ar}. \quad . \quad . \quad . \quad . \quad . \quad (129)$$

Here observe that **q** is the velocity of the point O, or of any other point on the axis of rotation passing through the point O. We may infer from this that if we shift the origin O to Q, a point on a parallel axis, equation (129) will still be true, provided **r** means the vector from the new origin Q to P, and **q** means the translational velocity of Q itself. Of course, the

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axis of rotation is now through Q. We may formally prove it thus. Take

$$\mathbf{r} = \mathbf{h} + \mathbf{R}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (130)$$

where **h** is the vector from O to Q and **R** the vector from Q to P. Put (130) in (129), then

$$\mathbf{v} = \mathbf{q} + \mathrm{V}\mathbf{a}\mathbf{h} + \mathrm{V}\mathbf{a}\mathbf{R}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (131)$$

But here $\mathbf{q} + \mathrm{V}\mathbf{a}\mathbf{h}$ is, by (129), the velocity of Q, say **u**, so we have

$$\mathbf{v} = \mathbf{u} + \mathrm{V}\mathbf{a}\mathbf{R}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (132)$$

showing the velocity of P to be the sum of the translational velocity **u** at *any* point Q, plus the velocity at P due to rotation about the axis through Q.

All motion is relative. But observe the absolute character of the spin **a**. It is absolute just because it involves and depends entirely upon relative motions.

The translational velocity **u** of the point Q consists of a motion along the axis of rotation, combined with a transverse motion. The latter may be got rid of by shifting the axis. For if **w** is the velocity of Q transverse to the axis, if we go to the distance w/a from the axis through Q, keeping in the plane through the axis perpendicular to **w**, we shall reach a place where the velocity due to the rotation about the Q axis is either $+\mathbf{w}$ or $-\mathbf{w}$, according to which side of the Q axis we go. Choosing the latter, where the transverse motion is cancelled, and transferring the axis to it, we see that the general motion of a rigid body consists of a spin about a certain axis (which is termed the central axis), combined with a translation along this axis. That is, it is a screw motion. It may, however, be more convenient not to employ the screw motion with a shifting axis, but to use (132), and let **u** and **a** be the translational and rotational velocities of a point Q fixed in the body.

We may also have simultaneous spins about axes which do not meet. Thus, let **R** be the vector from any origin O to a point Q about which there is a spin **a**, and **r** the vector from O to any other point P. Then the velocity of P due to the spin is, by the preceding,

$$\mathbf{v} = \mathrm{V}\mathbf{a}(\mathbf{r} - \mathbf{R}). \quad . \quad . \quad . \quad . \quad . \quad . \quad (133)$$

Next let there be any number of points of the type Q, each with its spin vector **a**. The velocity at P is then the sum of terms of the type (133), in which **r** is the same for all. The result is therefore

$$\mathbf{v} = \mathrm{V}\mathbf{A}\mathbf{r} - \Sigma\,\mathrm{V}\mathbf{a}\mathbf{R}, \quad . \quad . \quad . \quad . \quad (134)$$

where **A** is the sum of the **a**'s, or *the* spin of the body, whilst the *minus* summation expresses the velocity at O. For example, two equal spins, **a**, in opposite senses about parallel axes at distance h combine to make a mere translational velocity perpendicular to the plane of the axes; speed ah. I give these examples, in passing, to illustrate the working of vectors. These transformations are effected with a facility and a simplicity of ideas which put to shame the Cartesian processes. It may, indeed, be regarded as indicative of a mental deficiency to be unable to readily work the Cartesian processes—which is in fact my own case. But that does not alter the fact that if a man is not skilful in Cartesians, he may get along very well in vectors, and that the skilful mathematician who can play with Cartesians of great complexity, could as easily do far more difficult work in vectors, if he would only get over the elements, and accustom himself to the vectors as he had to do to the other method.

§ **124.** Going back to (127), we should, when the property whose time-variation is followed belongs to matter moving as a rigid body, employ in it the special reckoning of **v** of equation (132), giving the velocity of any point P in terms of **u** and **a** at an invariable point Q in the body. Thus, we have

$$\frac{dw}{dt} = \frac{\delta w}{\delta t} - (\mathbf{u} + \mathrm{V}\mathbf{a}\mathbf{R})\nabla.w. \quad . \quad . \quad . \quad (135)$$

But equation (127) applies not merely to the case of matter moving through space, carrying some property with it, but also when the matter itself is fixed, whilst some measurable property or quality moves through the matter, or is transferred from one part of the matter to another. And here we may leave out the consideration of matter altogether, and think only of some stationary medium which can support and through which the phenomenon can be transferred.

Thus, we may have a system of electric displacement **D** in a dielectric, which may be moving through it independently of any motion it may possess, and apply (127) to calculate $\dot{\mathbf{D}}$. It is, however, only in relatively simple cases that this can be followed up. For it is implied that we know the motion of the displacement and how it changes in itself, and these may be things to be found out.

But should the displacement system move as a rigid body, the matter is greatly simplified. This will occur when the sources of the displacement (electrification, for instance) move as a rigid body, and the motion is of a steady type, so long continued that the displacement itself (in the moving system) is steady. Writing **D** for w in (135), we shall have

$$\frac{d\mathbf{D}}{dt} = \mathrm{V}\mathbf{a}\mathbf{D} - (\mathbf{u} + \mathrm{V}\mathbf{a}\mathbf{R})\nabla.\mathbf{D} \quad . \quad . \quad . \quad . \quad (136)$$

Here $\mathrm{V}\mathbf{a}\mathbf{D}$ is the rate of time-variation of the displacement in a moving element of the displacement system, caused by the rotation. It is zero when the displacement is parallel to the axis of spin, and a maximum when it points straight away from the axis, like the spoke of a wheel.

The displacement system is, however, not necessarily or usually the same when in steady motion as when at rest. In the latter case only can it be regarded as known initially. Set it steadily moving and it will (by reason of the self-induction) be changed to another displacement system. Nevertheless (136), along with the electromagnetic equations, enable us to find the new displacement system.

Should, however, the velocities of the connected sources be only a very small fraction of the speed of propagation of disturbances through the medium, the re-adjustment of the displacement as the sources move takes place practically instantaneously (as if the speed of propagation were infinite), so that the displacement system remains unchanged, preserving its stationary type, whilst it moves through the medium as a rigid body, in rigid connection with the sources. (This is obviously quite incorrect at a great distance from the sources, but there the effects themselves are insensible.) In this case, too, it is clearly unnecessary that the motion of the sources should be steady. Thus, in (136), **D** becomes the known displacement system (of equilibrium), moving as defined by **u** and **a**, which may vary anyhow.

Similar considerations apply to systems of induction, moving with their sources. A general caution, however, is necessary when there are conductors or other bodies in the field, not containing sources. To keep them from having currents induced in them, or in other ways upsetting the regularity of the moving system, they should also partake in the motion, by rigid connection.

§ **125.** Equation (136) also applies to the motion through a medium of a "strain-figure," treated of by Dr. C. V. Burton in the current number of the *Phil. Mag.* (February, 1892). It is similar to that of slow motion of an electrical displacement system. Imagine a stationary infinite elastic medium with inertia, somehow set into a strained state, and let the speed of propagation of disturbances of strain be practically infinite. If then the strain-figure can move about through the medium, it will do so as a rigid body, provided the sources of the strain do so. In the above, **D** may signify the displacement (ordinary), whose variation in space constitutes the strain. Then $\dot{\mathbf{D}}$ is the velocity of displacement, and is expressed in terms of the velocity of the strain-figure. From the expression for the kinetic energy of the complete strain-figure, the mechanical forces concerned can be deduced. As this is to be done on dynamical principles involving Newton's laws, we may expect beforehand that a strain-figure symmetrical with respect to a centre will behave as a Newtonian point mass; as does a similar electrical displacement figure. But, in general, without symmetry, the calculation of the forces concerned would be very troublesome indeed.

But the real difficulty appears to me to be rather of a physical than a mathematical nature. We have first to get some idea of how the strain-figure is kept up. Let it be

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stationary first. Then the strain-figure is referred to a forced or unnatural state of the medium in certain places. At any rate, we require intrinsic "sources" somewhere, and perhaps it might for this reason be convenient to consider these portions of the medium (with the sources) to constitute the atom or molecule, rather than the whole strain-figure.

Now, having got a stationary strain-figure, how is it to be set moving? Three ways suggest themselves. First, a bodily motion of the medium carrying the strain-figure with it. This is plainly inadmissible. Next a motion of the atomic portions only of the medium (with the sources) through the rest of the medium, either disturbing it to some extent near by, or not disturbing it at all—slipping through, so to speak. This would carry on the strain-figure. But it is inadmissible, if it be our object not to move the medium at all in any part. Thirdly, we may keep the whole medium at rest, and cause the sources themselves to move through it, so that the atomic portions of the medium change. But there is no means for doing this presented to our consideration. It lies beyond the dynamical question of the forces on an atom brought into play if the strain-figure can move in the manner supposed. The second course above, on the other hand, is more intelligible, although it implies something akin to liquidity.

These objections are, however, only made suggestively. The matter is sufficiently important to be deserving of a thorough threshing out.

(To be continued.)

HERTZ OSCILLATIONS.*

BY A. PEROT.

In a recent article† M. V. Bjerknes has shown that the oscillations of electromotive force produced in the neighbourhood of conducting wires by Hertz's method could be represented by the expression

$$Y = A e^{-a(t-\phi)} \sin \pi \left(\frac{t}{\tau} - \phi\right).$$

I propose to carry out similar investigations in the case of an excitation different to that employed by M. Bjerknes, namely, that used by M. Blondlot‡ in his recent researches, slightly modifying it. In the apparatus which I used the oscillations were propagated through the wires of a *completely closed* circuit, comprising the following parts:—The region where the oscillations originated, a copper wire about 8m. long stretched horizontally; a movable bridge, connecting this wire to another one stretched parallel to it at a distance of 10cm.; a fine stretched iron wire, about 80m. long, connected this second copper wire to the spot where the oscillations were produced. In this way the opposite waves of E.M.F. given out by the exciter were propagated in either direction through this circuit, and interfered in the iron wire and not in the copper wires, owing, firstly, to the rapid damping of the oscillations, and, secondly, to the diminution of strength with the distance traversed. Two opposite points, A and B, of the line were connected to the two terminals of a spark micrometer, giving the 500th of a millimetre.

With things arranged in this manner, the bridge being in any position, and the micrometer not sparking, I moved the point so as to obtain a continuous flow of sparks. The sparking distance measures, under these conditions, according to Warren de la Rue and Müller, the square of the maximum difference of potential between the points A and B. Varying the position of the bridge, we were able to see that this sparking distance d varied with the distance a of the points A and B measured along the wires of the circuit. We could, therefore, construct the curve $d = f(a)$ point by point.

The figure shows one of these curves.

I obtained seven of these curves with different exciters, the maxima and minima of d for each of them are contained in the following table:—

Curves.	a.			λ
	1st Maximum.	2nd Minimum.	2nd Maximum.	
1	470 cm.	950 cm.	...	950 cm.
2	470 „	960 „	1,440 cm.	960 „
3	470 „	940 „	1,400 „	940 „
4	580 „	1,140 „	...	1,150 „
5	640 „	1,320 „	...	1,300 „
6	960 „	...	...	1,920 „
7	1,100 „	...	...	2,200 „

The curve has a very regular appearance, and presents decreasing maxima and increasing minima. The distances from the origin (first minimum) to the first maximum, and from one maximum to the second minimum, are equal. Hence, if we assume the electromotive forces Y_1 at B and Y_2 at A, given by the equations

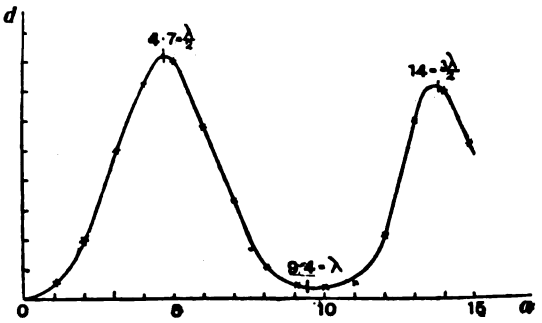
$$Y_1 = \phi(t) = C e^{-at} \sin 2\pi \frac{t}{\tau},$$

$$Y_2 = \phi\left(t + \frac{a}{V}\right),$$

and d proportional to the maximum value of $(Y_1 - Y_2)^2$, it is easy to construct the curve $d = f(a)$, which presents equidistant maxima and minima, the respective values of which are

$$D\left(1 + e^{-\frac{2n+1}{2} a\tau}\right), D\left(1 - e^{n a \tau}\right),$$

n being a whole number.



The calculated curve does not differ sensibly from the observed curve; and it is worthy of notice that the values of the logarithmic decrement $a\tau$, deduced from the comparison of the minimum and of the two maxima are, ·49 and ·46. The proposed formula, therefore, well represents the experiment. The electromotive force is of the order of a *simple damped pendulum*, and does not correspond to a complex sound. The damping is, moreover, very rapid. During the fourth period the electromotive force is only one-tenth of what it was at the commencement.

With this apparatus is it possible to excite a resonator and to measure its wave length? The experiment, which is in the affirmative on all points, is worth describing, the conditions being different to those under which M. Blondlot worked. The waves traversed the two-line wires in opposite directions, acting on the resonator at very different instants of time and in a very unequal manner, owing to the presence of the 80m. wire, which formed a sort of lateral loop. I was able with exciters, giving wave-lengths of 22m. to 13m., to excite a resonator and to measure its wave-length. The numbers found, 8·6m. and 8·3m., are identical to within ·035. I have even in the course of other researches been able to excite a resonator for which $\lambda = 1{\cdot}9$m., by an exciter, the wave length of which was about 30m.

In these experiments it is impossible, I think, to explain the phenomenon of *multiple resonance* otherwise than M. Poincaré* conceived it and MM. Bjerknes and M. Blondlot assumed it.

* *Compte Rendus*, Vol. CXIV., No. 4.

† Bjerknes, *Archives des Sciences Physiques et Naturelles*, Vol. XXVI., p. 227; and *Wied. Ann.*, Vol. XLIV., pp. 74 and 92.

‡ Blondlot, *Journal de Physique*, t. X., 2nd series, p. 549. (See note on p. 553.)

* Poincaré, *Archives des Sciences Physics et Naturelles*, t. XXV., p. 609. Bjerknes and Blondlot, *loc. cit.*

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METRIC WEIGHTS AND MEASURES.

BY J. EMERSON DOWSON.

It is no doubt pleasant to be amused, either in a Royal Institution lecture, or in a Note in *The Electrician*, even at the expense of one's convictions; and it seems to me a point in favour of the metric system that it can lend itself to such treatment. At the same time there is a serious side to the question, and as prominence has recently been given to Mr. Coleman Sellers's view of the subject, I crave leave to state briefly the reasons for adopting the metric weights and measures in this country.

In your Note it is stated, "We are constantly being told that some semi-barbarous country has adopted the metric system, among other fashions of civilization; and that this market or that will only purchase stove pipes that will fit a metrically designed stove, or hat bands a certain number of centimetres in depth." In reply, I think I cannot do better than give the following list, up to date, of the countries actually using the metric weights and measures:—

Country.	Population.	Country.	Population.
Norway and Sweden..	6,774,409	Austrian Territories...	41,827,700
Denmark and Iceland..	2,244,650	Greece	2,187,208
Danish West Indies ...	33,763	Roumania	5,376,000
Germany.....	46,855,704	Turkey (in Europe)...	4.668,000
Holland	4,450,870	Mexico	10,447,974
Java, &c.....	28,500,000	Central America	3,053,000
Belgium	6,030,043	Haiti	550,000
France	38,218,903	Colombia (Republic)...	3,500,000
Algeria	3,817,460	Venezuela	2,121,988
Senegambia	1,000,000	Ecuador.....	1,000,000
Portugal..	4,306,554	Brazil	14,000,000
Azores and Madeira ...	401,624	Uruguay	700,000
Spain—		Argentine Republic ...	4,200,000
Canary Islands.....		Chili	2,665,926
Fernando Po.....	17,550,216	Peru	2,970,000
West India Islands.		Japan.....	34,338,000
Philippine Islands..			
Italy	29,699,781	Total	323,489,773

It must be admitted that in this total population of over 323 millions the proportion of semi-barbarians is small, unless we are to include under this denomination all those nations which have shewn themselves in advance of ourselves by adopting the metric system introduced by France.

In Russia there is a strong disposition to adopt the metric system, and the Government has already decided to begin in certain directions. In Finland it has been compulsory since the beginning of this year. Col. Howard Vincent, M.P., has just visited China, and reports that "a recommendation is about to go forward from a high authority, to whom attention is paid, that China should adopt, as Japan has already done, the metric system of measurement of France and Germany."

The question of adopting the metric weights and measures in the United States is also receiving serious attention, and in July, 1890, the President transmitted to Congress a letter from Secretary Blaine, accompanied by a Report on Weights and Measures, unanimously adopted by the International American Conference. Mr. Blaine in his letter says:—

"This Report recommends the adoption by the United States of the Metrical Decimal System of Weights and Measures, which is now in use by the Governments and people of all the other American Republics and most of the nations of Europe, and which is already authorised by the laws of the United States. The adoption of this system in the Customs' service would, it is believed, greatly promote the public convenience."

We see then that at the present time all the leading countries of the world, except Russia and those where the English language is spoken, have already adopted the metric system, and that in Russia and the United States the question is being seriously considered. It would certainly be adopted at once in those countries if England were to adopt it.

We are, therefore, within measurable distance of having an international system of weights and measures, if only England will take the necessary step, and no one can dispute the advantage this would be to all concerned. It may, however, be said that this is only the dream of the impetuous reformer, and that we can well afford to stand aloof, or be left severely alone. I will endeavour to show that from a commercial point of view such a policy of isolation would be suicidal, and even at the present time I believe it to be prejudicial. Foreign buyers naturally prefer to deal in weights and measures they are familiar with, rather than be perplexed and worried by such arbitrary and complicated odds and ends as are used in this country. We have already seen that a large proportion of the nations with whom it is our interest to trade, *e.g.*, all the States of South America, now use the metric weights and measures. On the other hand, the manufacturers of France and Germany, to say nothing of Belgium, Italy, &c., all use the metric system also, and are therefore able to offer goods and machines which, without extra trouble or expense, have been made according to the metric weights and measures, and on this account we are gradually being placed at a disadvantage. Formerly we had a greater command over foreign markets than at present, but of late years most of the European countries have increased their powers of production, and are now energetically pushing the sale of their wares abroad. Germany especially is unceasing in her efforts to compete with us, and the fact that she and the other countries referred to use weights and measures which nearly all foreign buyers now prefer, gives them an advantage we can ill afford to allow.

I will give some authorities for these statements. The Foreign Office Report No. 180, dated 1st August, 1890, on subjects of general interest in Italy, says:—

"Manufacturers state that the exertions of German travellers to push their trade are indefatigable, and, as they are always anxious to comply with the desires of their customers, they are often successful, while British firms, instead of travellers, forward catalogues, which are of little or no use, especially as they are for the most part drawn up in English, and *prices are quoted in English weights and measures.*"

In the British Consular Report on the trade of Japan, No. 922, of July last, it is pointed out that preference is now given to manufacturers of machines and materials who use the metric system. This is confirmed by Col. Howard Vincent, in his recent report addressed to the Master Cutler of Sheffield. He says:—

"The Director of the Imperial Japanese Artillery (Lieut.-Col. T. Ota), an experienced officer with European training, expressed himself as fully sensible of the excellence of the metal manufactures of Sheffield, and of their superiority in cost, quality, workmanship, and originality of design. Notwithstanding these advantages, he considered it so easy for mistakes to be made in the measurements by feet and inches that, when exact dimensions were important, his Government preferred to order their material from Creuzot in France and Krupp in Germany, where the metric system is used, so that they may be relieved of trouble and anxiety."

In December last the Consul-General for Peru in London gave public notice that in future it would be necessary to comply with the following regulations in making out consular invoices:—

"In invoices of articles made of cotton, wool, linen, or silk, the length of each piece contained in the packages must be given in metres. In all cases the weight in kilograms must be declared on the invoice."

In September last the British Vice-Consul at Alexandria reported that:—

"The English technical terms, weights and measures, were utterly unintelligible to a large proportion of the persons to whom merchants in this country forward their circulars and price lists."

He strongly advised English export houses to use the metric system, and to adjust their quotations to the requirements of Egyptian customers.

In speaking of the importance of adopting the metric weights and measures for goods exported to Mexico and to Central America, an able writer in the *Engineering and Mining Journal* of New York shrewdly remarks that the goods sent to these countries should be made in sizes and shapes the buyers are accustomed to, and he adds, "If we are going to contest with England the commercial control of this hemisphere, why should we not take advantage of her obstinacy, and, by suiting her customers, get them away from her?"

Much more might be said in favour of the adoption of the metric weights and measures in this country. To keep within the limits of a short article I have merely touched on

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the commercial and practical side of the question, and from this point of view alone, I think it must be conceded that no such narrow issue is involved as is inferred in the reference to "stove pipes and hat-bands." When a deputation of the Decimal Association waited on the Chancellor of the Exchequer in May last, Sir Wm. Thomson, who was one of the speakers, remarked that "a large part of the time and work in an engineer's office is devoted to calculations that would be unnecessary and that would be much simplified if we had the metric system." Many ingenious proposals have been made for decimalising some of our existing weights and measures; and doubtless some of them would greatly improve those now in use; but I entirely agree with the Select Committee of 1862 that "it would involve almost as much difficulty to create a special decimal system of our own, as simply to adopt the metric decimal system in common with other nations. And if we did so create a special national system, we should, in all likelihood, have to change it again in a few years, as the commerce and intercourse between nations increased, into an international one." An ideal best is not possible; but next to this, the metric system certainly presents the greatest advantages and the fewest drawbacks, from many points of view.

I have not touched on the importance of the educational question involved, as this may not be considered within the province of a technical journal, such as *The Electrician*. I may, however, add that the Education Department has now fully recognised the need of giving instruction in the metric system, and the code issued last year provides that the principles of this system shall be taught in Standards V., VI. and VII. of the Primary Schools.

OBSERVATIONS OF ATMOSPHERIC ELECTRICITY FROM A CAPTIVE BALLOON.*

BY E. SEMMOLA.

These observations were made at Naples by means of the captive balloon *Uronia*. A vertical bar of brass half a metre long, terminated at the top by a brass disc 28cms. in diameter, was fixed to the car by a strong insulator. This disc communicated by means of a copper wire with the gold leaf of a dry battery electroscope placed in the car at about the same level. To this brass bar the upper end of a 2mm. copper conductor (*corde*) was soldered at several points, the conductor being enclosed within a double insulating covering—an inside one of india-rubber, an outside one of cotton. This conductor, 280m. in length, came down from the balloon and was arranged in long zigzags on a floor close to the ground; it was connected at the far end to a second dry battery electroscope. To avoid friction it was thought better to arrange the conductor in this manner than to wind it round a drum with a metal axis.

The day was calm and clear. At 9 a.m. the balloon ascended, carrying the conductor up with it, and in two minutes it reached an elevation of 280 metres, where it was maintained. During the ascent the gold leaf of the upper electroscope and that of the lower deflected towards the negative poles, both indicating, therefore, positive electricity; the deflection of the lower electroscope was, however, much the greater. A few seconds after the departure the gold leaf of the lower electroscope kept striking against the negative pole of the battery, and on being detached it immediately came into contact with it again. When the *Uronia* stopped at 280 metres elevation, the lower end of the copper conductor was put to earth, the observers in the car being warned by a whistle from the boiler of the traction locomotive. *Immediately after the whistle* the gold leaf of the lower electroscope remained vertical, and that of the upper electroscope turned *in a marked manner* towards the positive pole, indicating, therefore, negative electricity. When the earth communication was broken the lower gold leaf again deflected violently towards the negative pole, and that of the upper electroscope began once more to deflect slightly towards the negative pole. This observation was repeated several times and always with the same results.

On another occasion the lower end of the conductor was connected to a Palmieri electrometer. While the balloon was ascending the electrometer showed a uniform and regularly increasing deflection. At the elevation of 280m. the needle pointed to 50deg. As soon as the conductor was put to earth the needle went back to 0deg. The earth connection being broken, the needle deflected with a violent rush through an angle of more than 70deg.

This method allows us to discover the electric condition of the conductor at either end, and in this way to make simultaneous observations. Up till now observers have worked with a free balloon, or, remaining on the earth, have made use of a captive balloon, to take up a hanging copper conductor from the ground, where it was connected to an electrometer. In the latter case there were always indications of positive electricity. With a free balloon, carrying in the car all the apparatus which was thus insulated in space, the electricity observed was negative. This was the case in the memorable aerial voyage of Gay-Lussac and Biot, and in the ascent of the engineer Marcillac in 1886.

The method of simultaneous observations, using a captive balloon, should doubtless give better results than any obtained with the free balloon, which, in its rapid journey, at one time ascending, at another descending, continually changes the conditions, and can only yield complex and uncertain results, difficult to discuss.

* *Comptes Rendus*, Vol. CXIV., No. 7.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-NIGHT) FRIDAY, March 4th.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Ladies' Night. Concert at St. James's Hall Restaurant.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Surface-Film of Water, and its Relation to the Life of Plants and Animals." By Prof. L. C. Miall, F.L.S.

SATURDAY, March 5th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Matter at Rest and in Motion. By Lord Rayleigh, F.R.S.

MONDAY, March 7th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

SOCIETY OF ENGINEERS.

7:30 p.m. Ordinary Meeting. Paper to be read on "Electrical Traction and its Financial Aspect." By Stephen Sellon.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. III.—2. "The Uses of Petroleum in Prime Movers." By Prof. William Robinson, Assoc. M.Inst.C.E.

TUESDAY, March 8th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read with a view to discussion: "Petroleum Engines." By Prof. W. Cawthorne Unwin, F.R.S.

WEDNESDAY, March 9th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Experiments on the Durability of Modern Pigments." By A. P. Laurie, M.A.

THURSDAY, March 10th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Paper to be read: "Oil as an Insulator." By Prof. D. E. Hughes, F.R.S. Illustrated by experiments. Continuation of Discussion on Mr. A. Siemens' Paper.

FRIDAY, March 11th.

LONDON CHAMBER OF COMMERCE.

3.30 p.m. Meeting at the Mansion House: To consider the Chicago Exhibition.

PHYSICAL SOCIETY.

5 p.m. Ordinary Meeting. Papers to be read: (1) "Thermodynamics and the Action of Light on Silver." By H. M. Elder. (2) "On Choking Coils." By Prof. J. Perry, F.R.S.

CITY AND GUILDS OLD STUDENTS' ASSOCIATION.

8 p.m. Meeting at Central Institution. Paper to be read: "The Behaviour of Insulating Materials under the Action of High Potential Differences." By H. B. and W. Fox Bourne.

ROYAL INSTITUTION.

9 p.m. Evening Discourse "Japanesque." By F. T. Piggott.

SATURDAY, March 12th.

ROYAL INSTITUTION.

3 p.m. Afternoon Discourse: "Matter at Rest and in Motion." By Lord Rayleigh, F.R.S.

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The Electrician.

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HIGH-PRESSURE DISCHARGES.

While the intelligent public are still asking whether NIKOLA TESLA's lamps are ready for practical use, and while not a few householders are hesitating to wire their houses because they understand that the time is at hand when wires will be no longer needed, Prof. ELIHU THOMSON has turned his attention to the fascinating study of high-pressure discharges. An article in the *Electrical World* of New York, an abstract of which will be found elsewhere, describes a few of his experiments, and clearly sets forth the apparatus which has been employed. Prof. THOMSON has connected a large induction coil or transformer to an ordinary alternating-current supply circuit with 100 volts, and with a frequency of 125 or 250. This transformer apparently presented no special features, and yielded 10,000 to 12,000 volts, giving a half-inch spark. A condenser was connected across this secondary circuit, and this too seems to call for no remark. The large induction coil shown at the Paris Electrical Exhibition in 1881 was excited by an alternate-current dynamo; but induction coils have always been very uncertain in their behaviour, refusing to work at times with all the obstinacy of a HOLTZ machine, and too often the cause has been a complete breakdown of the insulation. Now that the art of insulation is much better carried out in commercial transformers than was ever thought of by the instrument makers who made large induction coils, there is little difficulty in providing 10,000 volts for experimental purposes. Prof. THOMSON connects in the secondary circuit another induction coil of a few turns. The primary consists of 15 to 20 convolutions of wire, and the secondary of 150 turns of fine silk-covered wire in one layer. It is needless to say that this coil is immersed in oil.

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On oil insulation must depend the success of all experiments such as those of Mr. Tesla, or of Prof. Elihu Thomson; and if only some solid insulating compound could be found which would not be acted upon by oil it is probable that all transformers would soon be enclosed in oil tanks. Those used at the Lauffen-Frankfort transmission experiments were so enclosed, and this system of insulation has been adopted in many other cases. The original Brooks system of oil insulation consisted in a serving of jute, which sufficed to keep the conductor away from the iron pipe in which it was enclosed, and in the use of mineral oil as the real insulator. The idea is very old, and was recommended by Mr. Lane Fox in the patent which has been the subject of so much argument before Mr. Justice Smith during the present week. Mr. Tesla uses linseed oil, and finds that it has a slow but definite action on gutta-percha. Prof. Elihu Thomson uses a silk covering for the wire, and a silk thread between the adjacent turns. Oil insulation will probably play an important part in the electrical engineering of the future, and it seems that little remains to be done to bring it into a practical form for even the highest pressure.

One of the features of the experiment with high potential discharges is the sparking distance of the secondary or tertiary circuit, and it is by this distance that the actual voltage may be guessed at. Unfortunately, the experiments which have been made on sparking distances have, with but a solitary exception, been made under purely laboratory conditions. That a ball, a disc and a point, carefully cleaned between each discharge, should be taken as a starting point in such an investigation is very proper; and this subject may be said to be fairly established now that Messrs. Siemens Bros. have succeeded in repeating Mr. De La Rue's experiments with close exactness. But under no cases but those of laboratory apparatus can the terminals of the spark gap remain clean, and under no conditions but those of laboratory experiments will these terminals be carefully cleaned after each discharge. In the design of lightning arresters on the evidence of such experiments, it is necessary to allow a very large factor of safety; for after a few months the points will become dirty, and the voltage required to produce a spark will probably be largely reduced. Spark distances with clean terminals tell us more about the dielectric properties of air than anything else, and from such experiments some very interesting purely scientific knowledge may no doubt be forthcoming. But for practical purposes, and for industrial and engineering applications of these high pressures, sparking distances must be studied under working conditions. Mr. Ferranti has made such experiments, and some of the results have been recorded in our columns. He found that after the lapse of one or even two minutes. a discharge might take place without any alteration in the pressure or the distance between the terminals. It is not possible that the air itself could gradually break down as a solid might, and it is unlikely that minute dust particles could form a bridge, as happens sometimes in oil. It is probable that a brush discharge oxidizes or even partly volatilizes the terminals, and may slightly heat the air, and that these circumstances facilitate the discharge. These conditions require further investigation, they are already of considerable importance in connection with electrostatic measuring instruments. Brilliant and interesting as the recent work of J. J. Thomson, Tesla, and Elihu Thomson have been, one of the firstfruits of the study of high-pressure induction discharges ought to be a more accurate knowledge of sparking distances under practical conditions; for it is not until this is established that any useful applications of this branch of electricity can be hoped for.

NOTES ON SUBMARINE CABLE WORK.

BY H. D. WILKINSON.

(*Continued from page 401.*)

2. The Mark Buoy.—The ship generally manages to reach the position of the fault some time in the morning, so as to get an altitude for the longitude of the position. A sounding is also taken, and the latitude is ascertained at noon. A steel mark buoy, such as shown in Fig. 6, and weighing about 18cwt., is then moored as nearly as possible over the position of the cable to act as a guide while grappling, and as a bearing to go by when the cable is hooked. The buoy is moored by means of a 3cwt. mushroom anchor (Fig. 7), this particular form of anchor having been found to hold well in almost any kind of bottom, and having no projecting points or arms, as in the ordinary anchor, which might foul with or chafe against the cable. This anchor is usually shackled to 15 fathoms of heavy chain ($\frac{7}{8}$in.) and the buoy rope attached to the end of the chain. The buoy rope is paid out till the

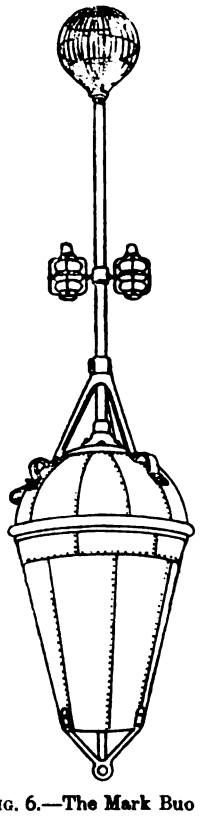

Fig. 6.—The Mark Buo

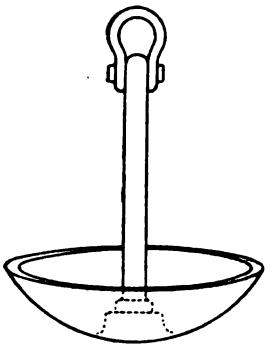

Fig. 7.—Mushroom Anchor.

anchor is within a few fathoms of the bottom, the end being then attached to the buoy chain on board. The bight is then thrown overboard and the buoy slipped, the slack chain allowing the anchor to reach bottom, and hold there. In deep water, for lightness, the buoy rope is of manilla, but as chafing is likely to occur on the bottom, it is customary to put in a length of 100 fathoms or more of compound steel wire rope. This is made with three cable-laid strands, each containing three steel wires, served with tarred manilla yarn, and known as 3 × 3 buoy rope. A length is also put in between the buoy chain and manilla rope, and in shallow water the compound rope is used throughout the whole length. The idea is, of course, to provide weight enough below to bed the anchor, and strength of rope sufficient to resist chafing, while at the same time lightness is a consideration, so as not to sink the buoy too far. If much overweighted, the buoy rapidly sinks; and buoys have been recovered from great depths where the enormous pressure of the water has entirely collapsed them. The buoy chain ($\frac{3}{4}$in.) is much lighter than the anchor chain. To the top of the buoy is riveted a holder for the beacon or flagstaff. During operations at night it is customary to lower a boat with hands

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to light the lamps on the buoy. As a boat fender the buoy is usually fitted with a belt of stout rope or packing a little above the water line.

3. Grappling.—The ship now leaves the buoy, and steams out about a mile, in a course at right angles to the line of cable, then lowers grapnel and steams back slowly up to cable, crossing

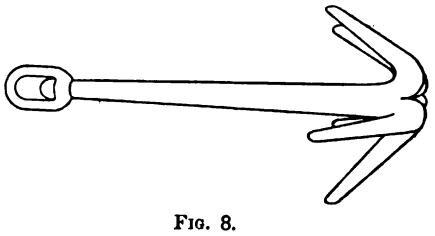

FIG. 8.

and recrossing it till hooked. The speed for grappling is about one or two knots an hour according to the bottom, and is slowest for a rocky bottom. Cable ships generally carry various kinds of grapnel to suit different conditions of bottom met with. The old form of 5 or 6-prong grapnel (Fig. 8) is still a very effectual grapnel for bottoms of a soft nature, such as sand or

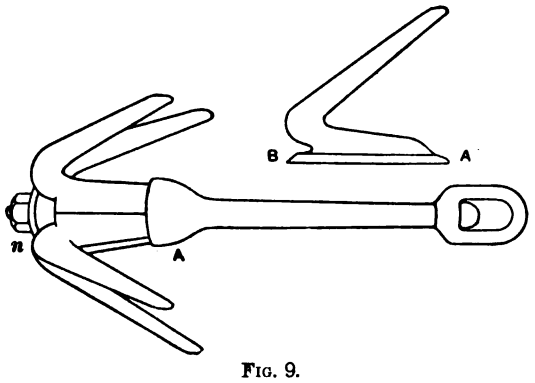

FIG. 9.

ooze; but meeting with any hard obstruction, such as rock, the prongs bend down or break off. To retain the use of the shank of the grapnel while the prongs are bent or broken off, many forms of grapnel with removable prongs have been devised. In one of these (Fig. 9), made by the Telegraph Construction and Maintenance Company, the prongs fit into a

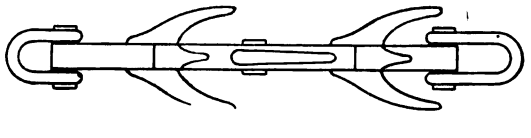

FIG. 9A.—Sliding Prong Centipede Grapnel.

hollow boss on the shank at A, and the ends at B are all enclosed by a collar and firmly fixed in position by the nut *n*. Another form, constructed by Messrs. Johnson and Phillips, is the sliding prong grapnel, and is provided with removable cast steel prongs of the kind shown in Fig. 9A. By taking the shackle off one end, the broken prongs may be slipped off and

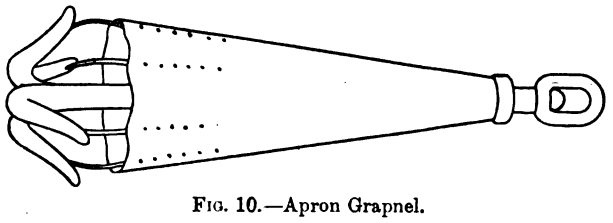

FIG. 10.—Apron Grapnel.

renewed. For rocky bottoms the Dutton apron grapnel (Fig. 10) is frequently used. In this grapnel the apron forms a guard for the prongs against breakage by rocks, and the opening between the prongs and the lower edge of the apron is only a little larger than required for the cable to enter. There are also retaining springs from the apron to the prongs. The grapnel in Fig. 11 has a guard for the same purpose, made of four wrought-iron arms. These guards prevent the cable getting out of the grapnel when it is jumping over uneven ground. The first form of this kind of grapnel was used in the "Great Eastern" when grappling for the lost end of the '65 Atlantic cable. This was made by lashing five

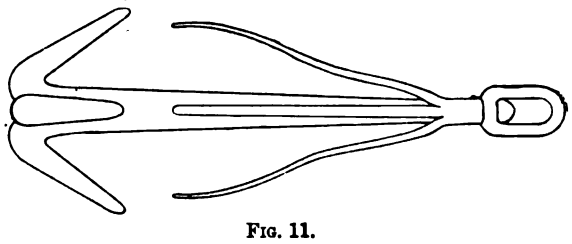

FIG. 11.

bent steel springs, about 1¼in. wide by $\frac{3}{16}$in. thick, to the stem of the grapnel, as shown (Fig. 11A). It will be remembered that the "Great Eastern," under the command of Captain (now Sir James) Anderson, laid the '65 Atlantic cable from Ireland towards Newfoundland, and that when about 1,180 miles from Valentia an electrical fault developed in the cable. In attempting to pick up and remove this fault the cable parted, the end

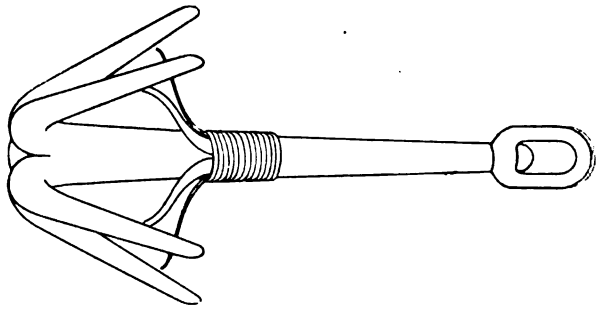

FIG. 11A.—Atlantic Cable Grapnel.

going overboard in 1,950 fathoms. This occurred on August 2nd of that year, and all attempts then made to recover it were ineffectual. But the "Great Eastern" returned in the following year, and, after successfully laying the '66 cable, went back to the position where the end of the former cable had been lost, and eventually raised the end, with the grapnel described, on September 2nd, completing the cable to Newfoundland in six days from that date. This was the first occasion on which a cable had been raised from a depth exceeding 500 fathoms.

(To be continued.)

CRYSTAL PALACE ELECTRICAL EXHIBITION.

The accompanying illustration represents the large steam dynamo, jointly exhibited at the Crystal Palace by Messrs. Johnson and Phillips and Messrs. Davey, Paxman and Co. The machine, which was designed by Mr. Kapp. has eight field poles, projecting radially inwards from a massive cast-iron yoke ring. The magnet cores, which are cylindrical, and 14½in. diameter, and the rectangular pole pieces, are also of cast iron. The armature core is 48in. diameter by 18in. long, and is built up of segmental plates, threaded on steel bolts and secured between strong cast-iron end cheeks. The power is transmitted to the armature conductors by 64 metal driving horns, insulated with fibre and mica; the force transmitted by each driving horn being about 50lb. There are 362 bars on the armature, and the ends are connected by segmental plates and insulated from each other and mounted in cast-iron carriages, which latter are screwed to the end cheeks above mentioned. This method of end connections has the advantage of leaving the ends of the armature perfectly open, which admits of excellent ventilation inside and of avoiding the crossing of conductors over the ends, which, in the old-fashioned way

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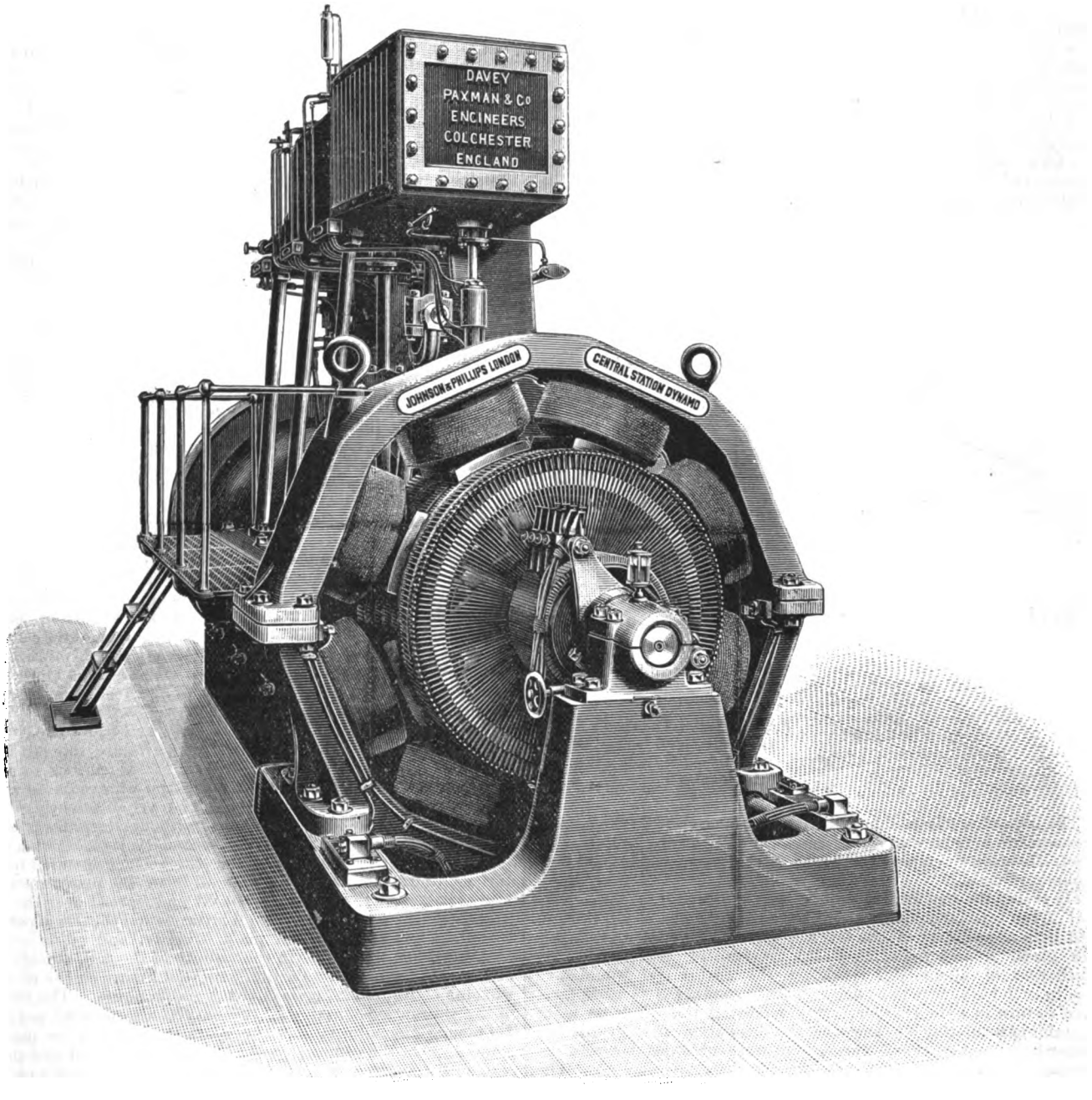
of drum winding, is so frequently a source of trouble. The difference between adjacent plates is only 10 volts.

The commutator contains 181 sections, and is 20in. in diameter and 12in. long. The current is taken off by two sets of brushes, placed 135deg. apart, four brushes in each set. The machine is designed for an output of 550 amperes, at a voltage which can be varied at will, from 200 to 260 volts, at 130 revolutions per minute; but as at the Palace a voltage of 205 volts only is required, the engine governor has been adjusted for a speed of 115 revolutions per minute. The brushes are adjustable by worm gearing. The current from the machine is used for lighting the Picture Gallery by incandescent lamps (which have been fitted up by the Gülcher Company), also for some Gülcher arc lamps, and for a number of Brockie-Pell lamps, as well as for driving all the machinery on Messrs. Johnson and Phillips' stand. For the latter purpose the current is passed through a pair of small balancing dynamos, which split up the current into 70 and 130 volts, so as to make the current suitable for charging cells.

The engine is triple-expansion, having cylinders 12in., 18¾in., and 30in. diameter respectively, with a stroke of 18in. It is built for an I.H.P. of 350 at 140 revolutions, or is 320 I.H.P. at 130 revolutions, and 160lb. steam pressure. The floor space, including platform, is 10ft. 6in. by 6ft. 9in., and from the floor line to top of cylinder covers is 11ft., the extreme height to top of sight-feed lubricators being 3ft. 2in. more; the platform is 2ft. 8in. above level floor. The steam is supplied from Paxman's water-tube boiler at 130lb. pressure; and for the purpose of starting the engine in any position steam can be admitted direct into the intermediate steam chest. The crank-shaft is of mild steel, with slotted cranks 120 degrees apart, and runs in four long bearings.



143 Kilowatt Multipolar Kapp Dynamo and Davey Paxman Triple-Expansion Engine.

The governor is of Paxman's improved design. The governor pulls over a link, bringing the short-throw eccentric into action with expansion valve spindle, and cuts off steam earlier, keeping the speed constant. The three main concentric rods are of best forged iron, finished bright, with adjustable bushes. The automatic gear is of steel, with forked joints fitted with steel pins. The piston-rods, crossheads, slippers, and valve spindles are of forged steel, the latter being swelled to work in guides. The connecting rods are of best forged iron. The fly-wheel is 6ft. diameter.

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INDUCTION BY HIGH-POTENTIAL DISCHARGES.*

BY ELIHU THOMSON.

In working to devise a means for the protection of electrical apparatus from the effects of induced discharges of lightning, it occurred to the writer to employ the inductive effects of the discharges, or, as it were, to interpose a barrier between the discharges and the apparatus to be protected. This gave rise to a lightning-discharge protector or lightning arrester, the principle of which is shown in Fig. 1. Let L be a line leading from a dynamo D, and subject to induction from lightning discharges, or subject to lightning discharges themselves, as in a railway trolley line. To avoid them he places between the dynamo and the line a double coil, each coil being made of a few turns of coarse wire highly insulated from each other. One of the coils may be wound upon the outside of a glass cylinder and the other coil may be wound in the interior. Both are connected to line at one end, as shown, and one or both are connected to earth through the discharge plates of a lightning arrester A, provided with an arc-rupturing device, such as a magnet to blow out the arc in case the potential of the dynamo is high enough to maintain such an arc. The coil in the dynamo circuit has been found to need a few more turns than that in the earth circuit, and the direction of winding in the two coils is such that they are opposed in their inductions.

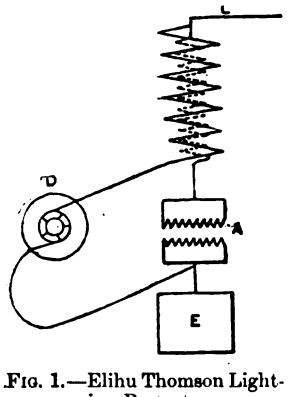

FIG. 1.—Elihu Thomson Lightning Protector.

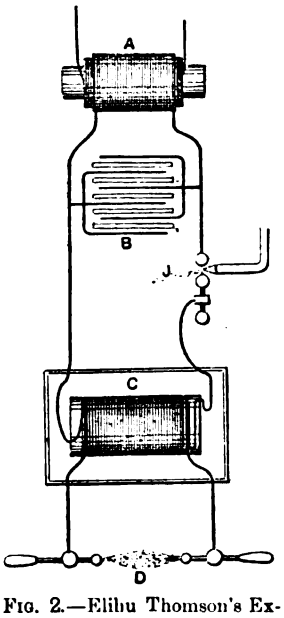

FIG. 2.—Elihu Thomson's Experiments on Electric Discharges. — Diagram of Arrangements.

The induction effects obtained with apparatus used in the experiments made in connection with this form of lightning protector led Prof. Thomson to employ condenser discharges in connection with Ruhmkorff coils.

On trying the experiment with a coarse heavily insulated wire coil of ten turns, enclosed in a glass tube, without any iron core, and with a secondary of one layer of fine silk-covered wire outside the glass, it was found that the passage of the Leyden jar discharges of about ¼in. spark in the coarse coil would give rise to such high inductive effects in the secondary as to spark from turn to turn in a single layer. By immersing the whole in a jar containing insulating oil, however, the insulation of the turns was better kept, and sparks of 2in. or 3in. were obtained between the terminals of the secondary at every discharge of the jar. The glass tube used was about 2in. in diameter and about 5in. long. There were about 120 turns in the secondary layer. The induction must have been at least as high as from 100 to 150 volts to the inch of wire. It was soon found that the glass tubes ¼in. thick were frequently punctured under the oil, and that the spark of the jar could not be unduly lengthened without producing discharges under the oil, or between turns of the secondary.

Arrangements were now made to obtain frequent condenser discharges at high potential, and to carry on the experiments on a much larger scale.

In Fig. 2 is a view of the apparatus used. A is a large induction coil or transformer, capable of using in its primary ordinary alternating lighting currents of 50 to 100 volts, and transforming up to 10,000 to 12,000 volts alternating. So used it will spark over one-half to one inch between its terminals and give the uprising thin arc now well known. A blast of air blown on such an arc changes it into a beautiful pale purple flame. A condenser B, the capacity of which can be changed, is connected to receive the current from the secondary of A. The spark or arc with moderate condensing capacity is not much changed unless a blast of air be blown upon it. In this latter case it displays a most beautiful electrical phenomenon. It becomes a mass of flame filled with fine and thick threads representing the condenser discharges, a gorgeous network of electric fire changing with any change of the pressure or direction of the air blast. Sometimes, as on breaking the primary circuit, the oscillations of charge and discharge are seen as minute parallel lines or sparks on the borders of the flame joining the terminals. With greater condensing surface the discharge between terminals becomes more thick and white even without the blast, and when a forcible air jet is turned on it roars very loudly. At C is a second and peculiar transformer, the primary of which is an open helix of but a few turns as 15 or 20 convolutions of heavily insulated line wire about four or five inches in diameter. This is surrounded by a thick glass cylinder, upon which has been wound say 150 turns of fine silk-covered wire in one layer, with a silk thread between the turns so as to cause the turns to be well insulated laterally. This simple induction coil is now immersed in a jar of heavy oil, and the terminals on leaving the oil kept as far apart as possible and surrounded by glass tubes. The terminals of the coarse and short primary are connected in circuit with the discharge balls upon which the jet of air plays at J. The finer secondary terminals are connected to discharge terminals as at D for obtaining the spark. On passing the alternating currents in the primary of A, and adjusting the spark gap and jet at J, as well as the distance between the discharge terminals at D, it is easy to obtain sparks of 7in. to 8in. in a perfect torrent at D, while sparks of ¼in. are passing at J.

The discharges obtained at D represent, it would appear, at least 150,000 volts in potential, or about a thousand volts to each turn of the secondary. The potential may be higher, for we have no data of spark length at such high pressures. It should be mentioned that the limit of spark was apparently that of the insulation of the secondary turns, for on attempting to increase it by separating the terminals at D to over 8in. the sparks jumped in the jar of oil, and could be seen passing under the oil from the secondary to the primary wires. Were it not for the required insulation between the turns of the fine wire secondary of C, they could be wound in one layer so as not to cover more than two or three inches of the glass cylinder, and could be made to give out sparks of a foot or more in length. The volts per inch of wire obtained in these experiments are extraordinary, and it is quite certain that the limit will depend on the insulation. We are now possessed of the means of obtaining artificial lightning in a steady stream, and can experiment at will with extremely high voltages. The advantages of oil insulation are emphasised by these experiments, and although sparks frequently passed under the oil the insulation is renewed at once.

It is necessary that the coil C be sunk well below the surface of the oil, as otherwise the discharges will perforate the oil layer at each end and pass over the surface. It is curious to note the agitation of the oil over the coil when the apparatus is in action and the coil is not deeply immersed and yet sufficiently so to prevent discharge. A curious discharge without electrodes is obtained by providing each terminal of the secondary layer C with a metal plate, which the oil just covers, the plates being parallel to the oil surface. Great agitation of the oil over the plates ensues, and sparks pass over the surface of the oil and spread over the surface just above the plates. If the oil layer be too thin it is perforated by discharges passing from plate to plate, and oil is scattered. Geissler tubes are lighted in the vicinity of the coil, outside the jar or near the terminals, an action long well known in the case in the working of Ruhmkorff coils of considerable power. The frequency of the alternations used was 125 or 250 alternations per second. By raising the alternations the spark torrent will be more continuous. On the completion of still more powerful and perfectly insulated apparatus the effects will doubtless be greatly enhanced.

The experiments demonstrate that lightning discharges, aside from electrostatic effect, may be the source of most vigorous electrodynamic inductions, and that high potential discharges may result.

* Abstract from *The Electrical World* of New York.

Institution of Electrical Engineers.—At a students' meeting held at the Library of the Institution on Friday, 26th ult., Mr. W. B. Esson presiding, Mr. Wharton read a Paper on "House-wiring." At the next meeting, on the 11th inst., two short Papers will be read—on "Electrometers," by Mr. M'Dowall, and on "Electric Welding," by Messrs. M. S. Poore and C. V. Drysdale.

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ON THE SPECIFICATION OF INSULATED CONDUCTORS FOR ELECTRIC LIGHTING AND OTHER PURPOSES.

The following is the authorised abstract of the discussion on the above Paper, read before the Institution of Electrical Engineers by Mr. W. H. Preece, on December 10, 1891 (see *The Electrician*, December 11, page 146).

THURSDAY, FEBRUARY 11TH.

Mr. PREECE said that some time having elapsed since reading his Paper he wished to add some further remarks to it. In the matter of india-rubber insulation durability was a quality which was quite as important as high insulation resistance. Though the initial insulation resistance might be very high, it by no means necessarily remained so; in fact, he always rather mistrusted rubber which had an abnormally high insulation; and in the case of gutta-percha it was well known that high resistance was generally accompanied by a want of durability. At the General Post Office rubber was tested by exposing it to a dry heat, 270° F., for one hour, and then to a moist heat, 320 F., for three hours. A rubber which stood this test could, he thought, be depended on to last some 15 years in a cable if not heated by an excess current. He had arranged that at the next meeting there should be exhibited some samples of rubber thus tested. Referring to oil insulation, he wished to call attention to a Paper read by Prof. Hughes in 1854, before the Society of Arts "On a Semi-Fluid Insulator," in which he proposed to cover a cable with gutta-percha or other substance, draw it into a pipe, and fill the latter up with oil or other semi fluid, pointing out that if the insulation was broken down it was immediately re-established. Referring to Mr. Siemens' Paper, Mr. Preece remarked that these tests were all on new cables, and must be taken as giving the limiting pressures they could bear under the best conditions. In practice it was necessary to allow for fissures in the insulation, the surfaces of the wire being dirty and the edges of the cracks possibly damp. He thought, therefore, that 500 volts per millimetre of insulation was probably as much as could be safely permitted in practice. Referring to the closeness between the results of Mr. Siemens and the previous ones of Mr. de la Rue, he said it was the first time he had ever found two experimenters who could agree about a sparking distance.

It was mentioned that at the next meeting Major Cardew would open the discussion, and show an electrometer method of measuring insulation resistances up to 250 000 ohms.

THURSDAY, FEBRUARY 18TH.

Major CARDEW showed an electrometer method of testing high insulation resistances. (See *The Electrician*, February 26, p. 430.)

Mr. ROBERTS, of the General Post Office, showed the apparatus used by that Department for testing rubber for durability. He mentioned that analysis had shown some samples tested to be adulterated with French chalk, pitch, resin, asphalt, silica, and old rubber. The samples were tested dry in a small copper oven heated by a gas jet to 220 F., and, wet, in an ordinary dentist's vulcaniser, also heated by a gas jet. This was half filled with water, the samples were placed in it, the top fastened down, and a safety-valve on the top, set to blow off a 90lb. pressure, which corresponds to a temperature of 320 F. The apparatus cost from £3 to £4. Samples which had passed these tests were shown, and also some which had failed.

Mr. GRAY thought Mr. Preece was mistaken in saying that engineers did not pay attention to the lasting properties of insulation in cables, as he thought they were fully alive to its importance. The figures given in the Silvertown lists were, he said, merely the minimum values. As the size of cables increased the thickness of insulation also increased, but not proportionately, and consequently the insulation resistance per mile was less in the larger sizes. He wished that some standard time of electrification could be agreed on in testing. One minute was most usually adopted, but some makers allowed five minutes. He believed in using high-battery power for tests; it broke down faults, but did not injure good cable. He considered the sparking distance in air had no bearing on the thickness of insulation required. Durability he considered to be in no way dependent on initial insulation resistance. He had a cable tested every fortnight for five years, which began with 9 (Preece) units of insulation and remained at the same figure still; another kept perfectly steady for the same time at 6 units; while a third, which began at 4, had fallen to ·4. Some high-insulation cable would, moreover, spark through at an E.M.F. which would not break down other cables of lower resistance. He did not consider that the heat tests applied by the General Post Office were by any means infallible. He had with him some samples of rubber which he had received from America. They were made from old ground-up galoshes, but they would pass the General Post Office heat tests perfectly.

Prof. FORBES said he was startled to hear Mr. Gray's last remark, but still thought that the test was a step in the right direction; even if all that passed it was not necessarily good rubber, it at any rate detected a good deal that was bad. He objected to Mr. Preece's statement that specific insulation resistance was not mentioned in specifications; a resistance of so many megohms per mile, when the diameter of core and thickness of covering was given, defined the specific resistance perfectly; but he agreed that Mr. Preece's method of expressing it was much more convenient. He quite agreed that high-insulation resistance was no criterion of durability. He did not believe in basing the thickness of insulation on the sparking distance in air, as this only came in in the case of a crack. Bad cable would crack, however thick the insulation, and a cracked cable was always dangerous. The proper thickness depended on mechanical considerations only. He believed the safest thing was to go to a manufacturer with a good reputation, and to trust to his not risking losing it by turning out bad work.

Mr. CROMPTON thought that Mr. Preece's specification would not mend matters much, and would prefer to trust to a maker's reputation. He considered the Board of Trade requirements quite insupportable. He had cable which passed all their requirements except thickness of insulation, which was better covered, and he considered much safer and more durable, than what they would pass. The latter, with its thicker insulation, was far more liable to kink and crack. To fulfil the Board of Trade requirements, makers would have to supply inferior insulating material on account of excessive cost. Engineers ought to combine to make a firm stand against the thickness required by the Board of Trade. What was wanted was a thin covering, of the very best material and make. Such a cable would never crack.

Mr. RAWORTH said it was rather a shock to hear that high insulation resistance was no proof of goodness. Referring to the numbering of cables, he said that at the Brush Company the wires were called according to the section in thousandths of a square inch, *e.g.*, 7/16 was No. 23. The number gave, therefore, the current the cable would carry at 1,000 amperes per square inch, and the number × 40 gave yards to the ohm. For alternating work he found a useful formula for leads was 2,000 volts on 2,000 yards of main; allowing 2 per cent. loss in mains meant 2lb. of copper for every two lamps.

Mr. SIEMENS referred to the influence of E.M.F. used in testing insulation resistance, and gave the following results:—

	R. with 100 cells.	R. with 1,200 cells.
Gutta-percha core	3.468 Ω	3.021 Ω
India-rubber core	8.054 „	6,245 „
Lead-covered cable	2.600 „	1.708 „
Ditto	2.600 „	2.200 „

High E.M.F.'s did not necessarily affect the insulation resistance of a cable, as he had some which was in daily use during the Frankfort Exhibition at 30,000 volts, and which came back with the resistance unaltered.

THURSDAY, FEBRUARY 25TH.

Mr. STEWART RUSSELL denied any connection between insulation resistance and durability, quoting cables of 14 and 0·6 Preece units respectively, which had lasted perfectly constant for 4½ years, while one of 3·8 came down to ·35 in the same time. Sparking distance in air was also quite irrelevant; for a good cable the air spark thickness was far greater than necessary, and for a cracked cable very much too small. Mr. Preece quoted the Board of Trade rules, but it was well known that these quite ignored quality, and their natural result was the use of thick bad quality insulation which would not last. The speaker then quoted some tests, showing that the E.M.F. to break a cable down did not vary directly with the specific resistance; also some on the effect of time in breaking down tests. From these he showed that a high pressure does not permanently alter the insulation of a cable unless there is an incipient fault. As a practical test he would measure the insulation resistance of a cable, then subject it for some time to three times its working pressure, and pass it if the insulation remained the same afterwards.

Mr. SWINBURNE said sparking distance in air had nothing to do with anything. In large wires the insulation was subject to approximately an even strain throughout its thickness; but in the case of a small wire the strain might be very uneven, being much greater, close to the wire, than at the outside. If anything, therefore, a small wire should have a thicker covering than a large one. When testing a long cable at high volts, the "condenser current" became large, necessitating a large dynamo; but this could be overcome by putting a big choking coil in series with the cable.

Mr. ESSON would allow 2 per cent. drop instead of 1 per cent. in the leads, as in Mr. Preece's specification, as only one-half the lamps would be on at once. He would also add a clause that the current should never exceed 1,000 amperes per square inch.

Mr. MAVOR instanced the case of a large order for cable which had been made with the utmost exactness to the specification based on experiments of the engineer who ordered it, and which failed completely. He objected to men without practical experience in cable manufacture specifying the thickness, &c., of insulation.

SOME EXPERIMENTAL INVESTIGATIONS OF ALTERNATE CURRENTS.*

BY ALEXANDER SIEMENS, MEMBER.

(*Continued from page 434.*)

In order to determine the variation of the efficiency of the transformers under investigation, it is necessary to treat separately the losses in the iron and in the copper. The former can be found by the aid of the curves on Diagram I., in combination with the curve giving the weight of iron necessary at the various inductions.

An example will best illustrate how this loss is ascertained in a case where the total mass of the iron is worked at the same induction, produced by a current of a frequency equal to 100 ∿ per second, the iron mass being composed of 1mm. wires. The loss in the normal transformer working with an induction B = 5,000, and

* Paper read Thursday, 11th February, 1892, before the Institution of Electrical Engineers.

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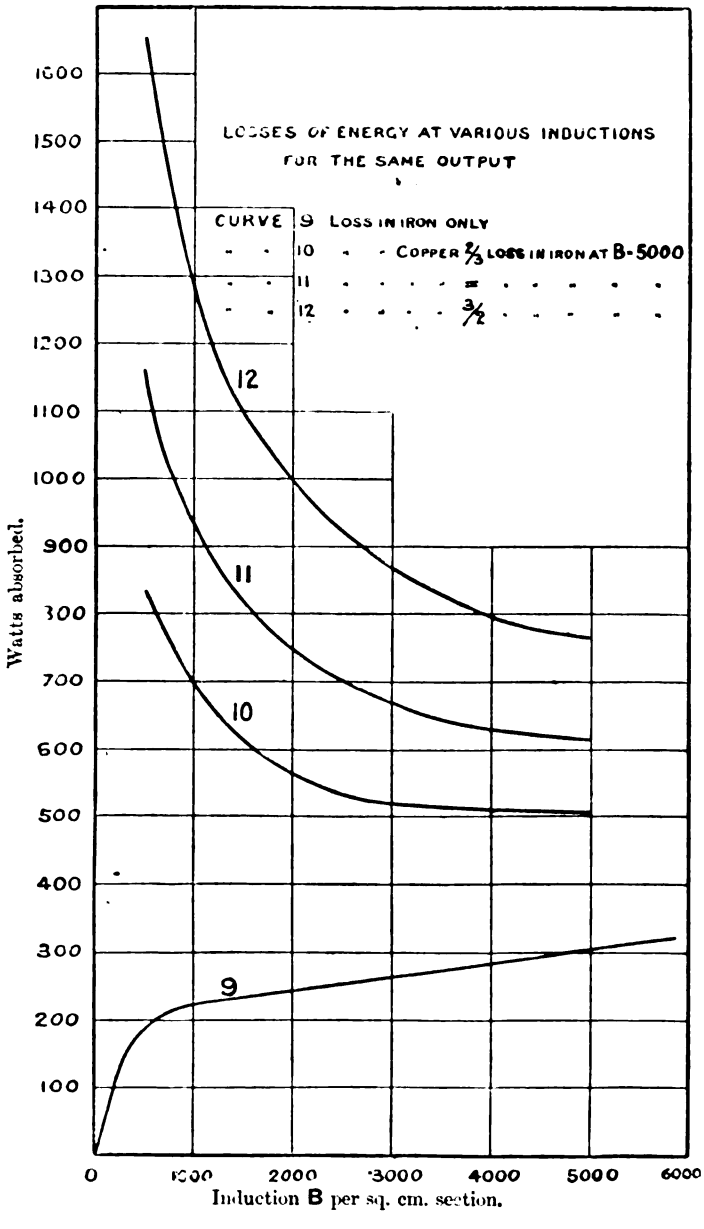
with a weight of iron=1 cwt., is 309·6 watts, according to Diagram I. For another transformer working with an induction B=2,500, the weight of iron, as shown by the curve (7), has to be increased to 2 cwt. ; at the same time the loss per cwt. is reduced to 126·8 watts, or the total loss is reduced to 253·6 watts.

In a similar manner the losses for the different inductions have been calculated, and the results are embodied in a curve (Diagram IV., No. 9) which indicates that the loss of energy in the cores of transformers increases with the strength of induction, at first rapidly, but after the induction has reached a value of B=1,000 the increase is very slow. As far as the loss of energy in the iron goes, it is therefore of not much consequence what induction between 1,000 and 5,000 lines per square cm. is used. The influence of the strength of induction on the loss of energy in the copper can be shown in the simplest manner by comparing this loss in the normal transformers designed for 5,000 lines with the loss in the other transformers of the series.

DIAGRAM IV.



There are evidently three possible cases for the normal transformer : the loss in the copper may be equal to the loss in the iron, or it may be greater, or it may be less. For each of these cases a curve can be plotted showing the sum of the losses in the iron and in the copper at the corresponding induction. If we take, for instance, the case that the losses in copper and in iron are equal, the total loss in the transformer having an induction B=5,000, is 2×309·6 watts. For the transformer having an induction B=2,500 the loss in the iron is given in our curve 9, and the loss in the copper is in proportion to its weight, which varies in accordance with curve 8, or, in this particular case, the loss is = $\sqrt{2}\times 309{\cdot}6$ watts. In this way curve 11, Diagram IV., has been plotted for the case of the losses being equal, curve 10 represents the case where the loss in the copper is equal to two-thirds of the loss in the iron, and curve 12 where the loss in the copper is 50 per cent. greater than the loss in the iron. Taking these curves to represent generally the variation of the total loss at the various inductions, it appears that, when keeping the loss in copper small in comparison with the loss in iron, it is quite possible to obtain about the same efficiency with any induction between 2,000 and 5,000 lines per square cm., but if a lower induction is used the efficiency, even on full load, decreases very rapidly.

From the consideration of efficiency it is, therefore, desirable to work the transformer with a high induction, and it is only the question of the heating of the apparatus which imposes restrictions on the use of high inductions, to avoid the destruction of the insulating material. In other words, the problem was to find the maximum internal temperature of a body of known dimensions when the rate at which its mass is heated has been determined.

In order to obtain some data towards the solution of this problem, a solenoid was constructed by winding 18lb. of insulated iron wire, 2·4mm. in diameter, on a brass tube 300mm. long, 8mm. internal diameter, and provided with flanges at the ends each 100mm. diameter. The internal temperature was measured by means of a thermometer just fitting the brass tube, and due care was taken to keep the temperature of the surrounding air constant during the experiments. A constant direct current was sent through the coil, and a reading of the thermometer was taken after it had ceased rising. The rate at which energy was supplied to the coil was determined by the product of the square of the current into the resistance of the coil, measured when the equilibrium of temperature had been attained. By varying the current the internal temperature could be varied, and the results were plotted in curve 13, the abscissæ of which represent the cooling surface in square centimetres per watt dissipated, and the ordinates indicate the excess of the internal temperature of the coil over the temperature of the surrounding air in degrees centigrade, after the equilibrium between the supply and the dissipation of energy had been established in each case.

This curve is a rectangular hyperbola of the equation, $x\,y=1{,}500$, and it shows that if the temperature of such a coil is to be kept at 100°C. the cooling surface should be 15 square cm. for each watt converted into heat in the coil. It is self-evident that this curve (Diagram V., No. 13) relates only to the coil by the aid of which it was constructed, and that it can only serve as a guide under strictly similar circumstances. By way of comparison a set of experiments was made on the same lines with a cable transformer, hung up in air, 6 metres long and 9·5cm. in diameter, the internal temperature of which was determined by means of a test wire, as described above. This curve (Diagram V., No. 14) shows that for an internal temperature of 100°C. a cooling surface of about 23 square cm. has to be provided per watt of energy converted into heat in the transformer.

Before it is possible to draw general conclusions as to the connection between the internal temperature of transformers and their cooling surface, it is obviously necessary to make a good many more experiments in the direction indicated by the two curves just described.

Last year Dr. Fleming read a Paper before this Institution, "On some Effects of Alternating-Current Flow in Circuits having Capacity and Self-Induction" (*Journal of the Institution of Electrical Engineers*, Vol. XX., No. 94, p. 374); it is, therefore, not necessary to repeat here the results of some experiments which were brought to the notice of the Institution at that time.

A very important factor in the construction of alternate-current apparatus is the striking distance of these currents in various materials, as this determines, in the case of high-voltage currents, the thickness of the insulating material with which the conductors have to be surrounded, the ohmic resistance being no guide.

The first set of these experiments referred to the striking distance in air. In all the experiments made the frequency of the alternate current was 100 ∿ per second, except where another frequency is specially mentioned, and the voltage was produced by means of an alternate-current machine and a transformer, and it was measured by one of Sir William Thomson's static voltmeters. The electrodes were re-polished each time a spark had passed between them ; one of them was fixed horizontally during the experiments, while the other could be advanced towards it from above by means of a micrometer screw which allowed of reading to a hundredth of a millimetre.

The experiments were made in the following manner :—After connecting the electrodes of the spark micrometer to the terminals of the transformer, a certain voltage was put on and accurately measured ; the distance between the electrodes was then slowly diminished until sparking occurred. Each experiment was repeated at least three times. Various electrodes were experimented with, the first pair being two plane parallel surfaces. In this case the fixed horizontal electrode consisted of a polished brass disc about 100mm. in diameter, while the movable electrode was also formed by a brass disc, but only 37mm. in diameter. To prevent the

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Diagram V.

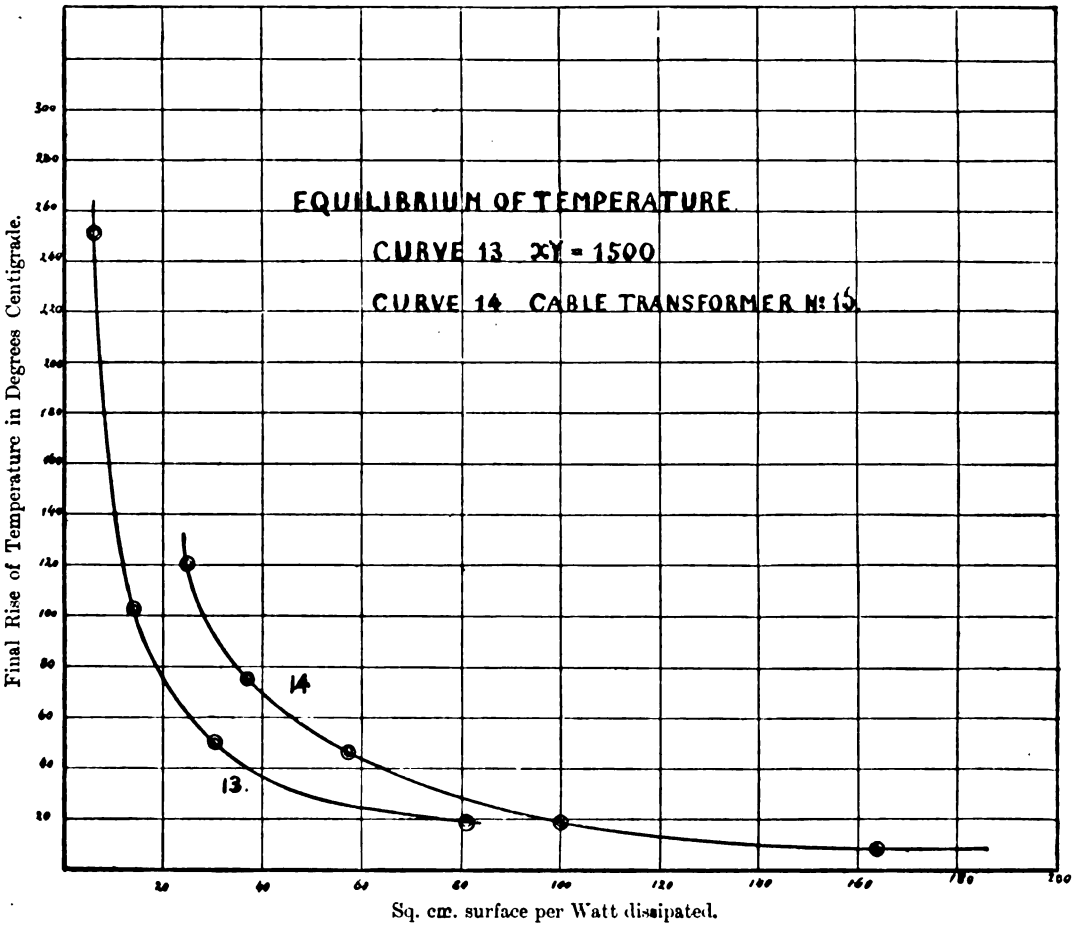
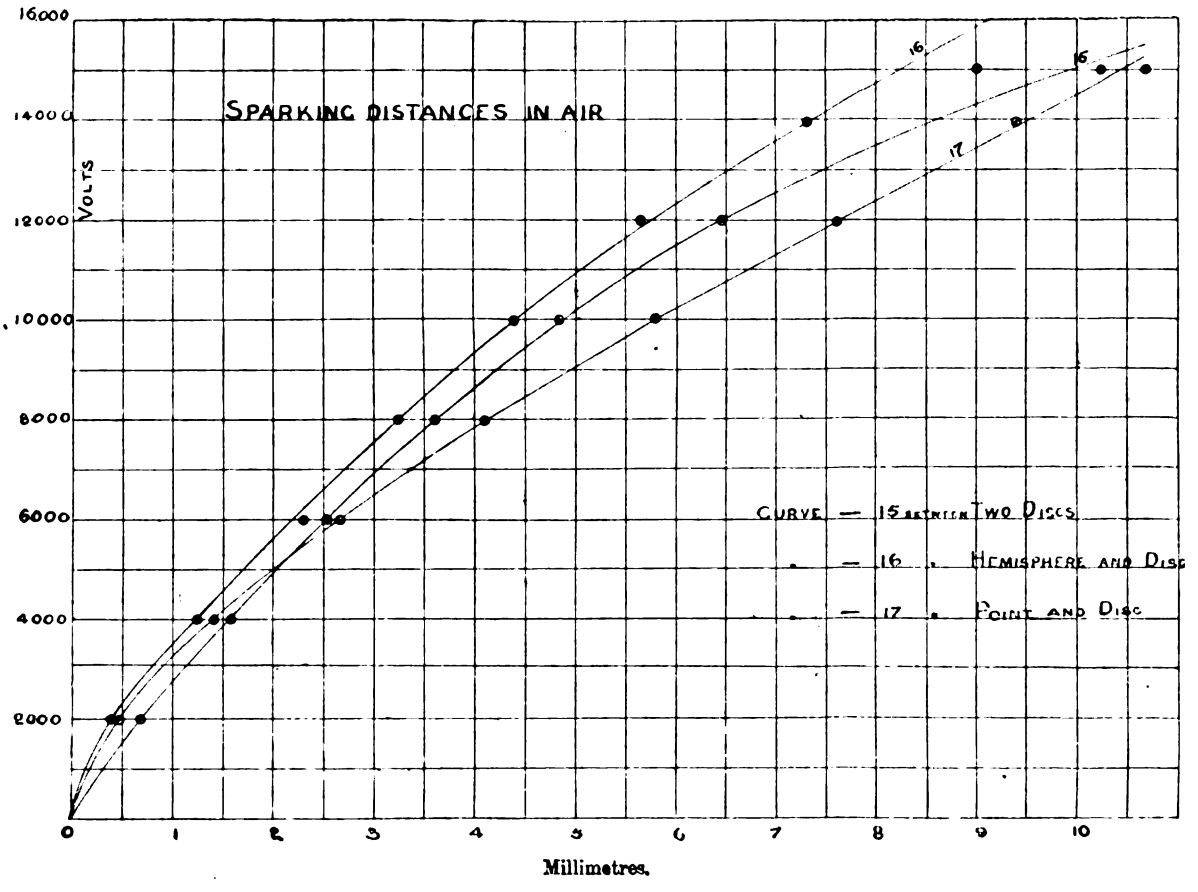

EQUILIBRIUM OF TEMPERATURE.
CURVE 13 XY = 1500
CURVE 14 CABLE TRANSFORMER No 15.
14
13.
Final Rise of Temperature in Degrees Centigrade.
Sq. cm. surface per Watt dissipated.

Diagram VI.



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action of sharp edges, the edges of the discs were rounded off. The temperature of the surrounding air during these experiments was 14·75°C.

The results obtained are as follow :—

Difference of potential.	Striking distance.	Difference of potential.	Striking distance.
volts.	mm.	volts.	mm.
2,000	0·67	10,000	4·80
4,000	1·59	12,000	6·46
6,000	2·53	15,000	10·23
8,000	3·60		

The last reading, giving the striking distance for 15,000 volts, cannot be correct, as the sparks started from the upper edge of the smaller disc, and not from the nearest points between the two discs, the smaller disc being placed above the fixed one.

Curve 15 (Diagram VI.) is the graphic representation of the above table.

For the next series the arrangements were the same as before, with the exception that the smaller movable disc was replaced by a half-sphere of 10mm. diameter. The temperature of the air during these experiments was from 16° to 17° C., and its humidity 80 per cent.

Difference of potential.	Striking distance.	Difference of potential.	Striking distance.
volts.	mm.	volts.	mm.
2,000	0·45	10,000	4·37
4,000	1·40	12,000	5·65
6,000	2·30	14,000	7·32
8,000	3·25	15,000	9·02

These results are plotted in curve 16 (Diagram VI.).

After this the movable electrode of the spark micrometer was replaced by a steel point of an angle of 60deg., its section being an equilateral triangle of 5 mm. sides. This point was also re-polished after each spark ; the spark, however, did not always start from the point. During these experiments the temperature of the air was 12° C., and its humidity about 50 per cent.

Difference of potential.	Striking distance.	Difference of potential.	Striking distance.
volts.	mm.	volts.	mm.
2,000	0·40	10,000	5·78
4,000	1·26	12,000	7·60
6,000	2·66	14,000	9·37
8,000	4·08	15,000	10·70

Curve 17 (Diagram VI.) embodies this tab'e.

After this the influence of an alteration in the frequency was tried by lowering this to 80 ∿ per second, and repeating some of the first experiments with disc electrodes. The striking distances for 4,000 volts and for 6,000 volts under these circumstances were found to be 1·47 mm. and 2·30 mm., or only slightly different from those produced by a frequency of 100 ∿ per second. From theoretical considerations it might have been expected that the distances would vary directly as the frequencies.

In order to investigate the influence of capacity, one or more coils of gutta-percha-covered wire were connected to the circuit of the transformer in parallel with the spark micrometer. The first experiments were made with a frequency of 100 ∿ per second, the two disc electrodes, and a capacity of 0·113 microfarad. The temperature of the air was 16·5°C., and its humidity 79 per cent.

Difference of potential.	Sparking distance.	
	With capacity.	Without capacity.
volts.	mm.	mm.
4,000	1·53	1·59
6,000	2·21	2·53
10,000	4·17	4·50

A further experiment under similar conditions, but with a capacity of 0·28 microfarad in circuit, showed that the sparking distance at 10,000 volts was further reduced to 3·94mm.

These tests were repeated with other electrodes, viz., the spherical surface and the disc.

At a difference of potential of 10,000 volts the sparking distance turned out to be—

1. With 0·14 microfarad capacity in circuit ..... 4·08mm.
2. Without any ,, ,, ... 4·50 ,,
3. With 0·14 microfarad ,, ,, ... 4·06 ,,

After that the steel point and the disc were used as electrodes, a capacity of 0·14 microfarad being connected to the circuit, and the results were :—

Difference of potential.	Sparking distance.	
	Without capacity.	With capacity.
volts.	mm.	mm.
4,000	1·26	1·14
10,000	5·78	4·83

All these experiments point to the fact that the sparking distances in air are diminished to a slight extent when capacity comes into play.

With a view of ascertaining how the voltage is propagated along a circuit, the position of the micrometer relatively to the cable was varied.

The experiments detailed above were made with the spark micrometer connected to the beginning of the cable ; they were afterwards repeated after inserting the spark micrometer in the middle of the cable, and again after it had been connected to the end of the cable. In all three positions the same striking distance was observed under similar circumstances, which tends to prove that the voltage is propagated uniformly over the whole length of conductor, even if there is capacity in some parts of the circuit.

As stated above, the voltage experimented with was measured by means of Sir William Thomson's static voltmeters ; but it is undoubtedly the highest ordinate of the wave which causes the spark. This "real" voltage can be found, if sine waves are assumed, by multiplying the measured volts by $\sqrt{2}$, and these new figures should be applicable to constant continuous currents.

In this way the results of curve 15 were corrected, and compared with some results published by Warren de la Rue in *Nature* on September 12, 1878. Assuming that the E.M.F. of his cells was equal to 1 03 volts, and reducing his results to volts and millimetres, they compare as follows :—

Difference of potential.	Striking distance.	
	Warren de la Rue.	Siemens.
volts.	mm.	mm.
2,000	0·45	0·25
4,000	0·95	0·80
6,000	1·55	1·45
8,000	2·15	2·15
10,000	2·85	2 85

On referring to the other curves published at the same time, it will be seen that Warren de la Rue found the sparking distances between two plane surfaces and between two spherical surfaces not to differ very much from each other. It may, therefore, be allowable to compare the mean values of these two curves of his with curve 16 for the sparking distance between a hemisphere and a plain surface after the values of the volts have been multiplied with $\sqrt{2}$.

Difference of potential.	Striking distance.	
	Warren de la Rue.	Siemens.
volts.	mm.	mm.
2,000	0·36	0·25
4,000	0·87	0·80
6,000	1·50	1·45
8,000	2·10	2·16
10,000	2·75	2·85

Both these tables show that the results are practically identical, and, consequently, it may be concluded that the secondary current of the transformer used for the experiments is really a sine function.

(To be continued.)

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LEGAL INTELLIGENCE.

Lane Fox v. Kensington and Knightsbridge Electric Lighting Company (Limited).

THURSDAY, FEBRUARY 25th.

Cross-examination of Prof. PERRY continued by Sir HORACE DAVEY: Do you remember telling us on Tuesday that you yourself used the Lane Fox system for the dining-room of the Grand Hotel, at Charing Cross?—Do you mean by that including the accumulators?

I will read you what you said:—"I myself used the Lane Fox system for first lighting up the dining-room of the Grand Hotel, at Charing-cross." Do you remember that?—Yes, and I meant to include accumulators.

And what you meant was the combination of accumulators with the Lane Fox system?—In the patent Lane Fox speaks of combining accumulators with his system.

At all events, I think we understood what you meant, and that my lord understood also. I want to know if the attempt was successful.—It was successful at the beginning.

For how long?—For a few days.

And then broke down?—No.

It was unsuccessful at the end?—We naturally added cells to prevent the lamps going a little too high and a little too low.

Did you not find it necessary at the Grand Hotel, Charing-cross, for the successful working of that system to introduce your arrangement, by means of switches or otherwise, by which you could throw certain cells in the accumulators out of use, and, when necessary, introduce other cells into use? Can you answer that, yes or no?—With our set of cells, yes. My set of cells was too small. I could have done it in two ways.

Cannot you answer my question? I will put it again, and I shall be much obliged, subject to my lord's direction, if you will be kind enough to give me a direct answer, yes or no. Did you find it necessary to introduce arrangements by which you might from time to time introduce fresh cells into operation or exclude cells from operation?—Yes.

But it was a small installation.—It was the largest then in use, I think.

But as compared with the installations for the present day it was a small installation.—Yes.

Mr. JUSTICE A. L. SMITH: Did you give the date for this?—I think it was at the end of 1882 or the beginning of 1883.

Sir HORACE DAVEY: Did you not try various devices for the purpose of bringing cells into action and throwing cells out, and did you not make serious experiments?—Yes, and took out patents for switches. Our main difficulty was the badness of our cells.

Now can you tell me of any single successful installation which has been made of the Lane Fox system described in the patent, I of course include accumulators—including the combination that is claimed—any successful installation of the combination claimed by Lane Fox in his patent, without introducing switches or other arrangements for regulating the number and altering and varying the number of cells which from time to time should be in operation?—Do you mean in use at the present day?

At any time since 1878—I consider my installation—— Oh, there is the one described which I spoke of as being at Glasgow University, and that was certainly successful.

Are you going to give any evidence on that—I mean, you know nothing more than the description in *The Electrician*, as I understand?—No.

Now you have told us that you have experimentally—I use your own language—"If your cells are to work at 100 volts you can charge those cells at 101 volts, because I have tested it experimentally." I should like a little further information about that, what was the nature of your experiment, you have tested it experimentally? Understand, the point is this: I am instructed by a gentleman who is conversant with the subject that, in order to charge a secondary battery fully, the charging current must be raised gradually from 100 to 125 volts; those are my instructions, and I will give evidence on that point, therefore I want to ask what are the experiments?—I have made several.

Mr. JUSTICE A. L. SMITH: You say you can charge it with 101?—Yes, my lord, 101, with a very small increase.

Sir HORACE DAVEY: Do you mean charge it completely?—I mean that your charging current—that when you current is charging—it need only be very little above the normal voltage, and when you discharge from the cells your leads get only a little less than the normal voltage.

Prof. PERRY then described experiments made with small currents and small cells, in one case on a single cell, and in another on 48 cells; the experiments lasted six or seven hours. He said that using a large battery comes to the same thing as using a smaller current. Switches for altering the number of cells were not required when large enough batteries were used.

Will you say as an electrician that earth alone—the soil alone, having regard to the large quantity of current which is required for the purpose of electric lighting—would be a sufficient return conductor?—Do you mean better than copper?

I ask you whether it would do at all?—It will work, and work quite successfully. If the Board of Trade would allow me, and I was distributing anything over two or three miles, I would use the earth as a conductor if the Board of Trade and insurance companies would let me. It is merely a question of the degree of cost.

[Witness produced "Munro and Jamieson's Pocket Book," in which the return circuit on board ship is called "earth."]

Prof. PERRY was re-examined by Mr. MOULTON: He described the process of charging and discharging a battery. He said that if an earth plate of platinum were used it might be very thin. In further cross-examination he said that if the range of variation in the Kensington batteries is 10 per cent., a battery twice as costly would have a range of about 5 per cent. He thought that plates five times the size would be sufficient to allow switches to be dispensed with. It was put to him by Sir HORACE DAVEY that the plates at Kensington are about a foot by fifteen inches. He was asked whether he had ever seen a plate five times this size? He replied that five times as many of the same size would do.

WITNESS was briefly re-examined by the ATTORNEY-GENERAL.

Mr. ST. GEORGE LANE FOX, examined by the ATTORNEY GENERAL, said that he carried on no profession, but had for many years studied electricity. He had managed practically manufactories and works, although he had not been solely dependent upon that for his living. He had taken out earlier patents before that of 1878, and had worked at distribution of electricity for other purposes, such as the lighting of a number of gas lamps. He was prepared to give any explanation or to answer Sir Horace Davey's questions as to why no proceedings were taken before. An action was brought before this one by the Brush Company, who owned his patents. It was afterwards compromised. The Brush Company brought an action against the Edison-Swan Company. It was begun in 1886.

Mr. JUSTICE A. L. SMITH: That was compromised?—Compromised. The Company acknowledged the patent and accepted a licence.

You mean the Edison Company "knocked under"?—Yes.

WITNESS then described the state of knowledge about electric lighting in 1878, and explained the difference between lamps arranged in series and in parallel. He explained that there was an important and essential difference in the idea disclosed in his patent. That was for a fixed current dividing itself into branches, whereas in his specification he thought he might safely say that a new idea was introduced unthought of at that date—the idea of a constant potential with a variable load.

The ATTORNEY-GENERAL:—For the purpose of "earth return" it does not make any difference whether the return is insulated or not?—It does not.

Mr. JUSTICE A. L. SMITH: What is an uninsulated wire?

The ATTORNEY-GENERAL: An uncovered wire; it would be what you may call a more ready path. May I put the question, my lord? Do substances vary in their conductivity?—Yes.

For instance, wood is either no conductor at all or a bad conductor?—Very bad.

Metal is very good?—Very good.

Mr. JUSTICE A. L. SMITH: What does he call the difference between an insulated return and an uninsulated return?

The ATTORNEY-GENERAL: Would a strip of copper put through the ground coming back from the lamp to the generator be an uninsulated return?—Quite so.

Would the electricity in fact pass back, as far as you know, through that copper?—Unless some of it leaked out.

Mr. JUSTICE A. L. SMITH: Now about an insulated one.

The ATTORNEY-GENERAL: Now, then, what would be an insulated return? Take the same strip of copper, what would you do with it to make it an insulated return?—I should surround it with some material like gutta-percha, through which the current will not pass. From the point of view of getting the current back to the generator, it does not make a particle of difference whether it comes back through an insulated return or an uninsulated return.

Now I call your attention, if you please, to the next line as it now stands—"The electromotive force of the electric conducting mains should be kept as nearly as possible constant at, say, 100 volts, or British Association units of electromotive force." First, are you aware of any English enunciation of the 100 volts as being about the right standard prior to your patent?—No.

You believe that was the first time that that direction had been enunciated?—Yes.

And you direct here that it may be kept as nearly as possible constant at, say, 100 volts. I wish to ask you this, does your present experience tell you whether that is about the right standard or not?—It is the standard universally adopted at the present day.

Is it the pressure at which the defendants, as well as a number of other companies, work the incandescent electric light now?—It is.

I wish to ask you, was your direction the result of your own experiment and research?—It was.

WITNESS then described Planté's battery and Faure's improvements. The Faure, which had flannel or felt to keep the oxide up by the side of the plate, was a type which was supposed at one time to be going to be very useful, but which has been entirely discarded. During the years 1881, 1882, 1883, and 1884, people were trying to use the improved batteries rather than using the Planté batteries.

The ATTORNEY-GENERAL: Now to-day, speaking with all your knowledge of to-day, which are the best for the purposes described in that specification? Planté's lead and sulphuric acid, or the pasted batteries which were referred to by Prof. Perry?—Planté's are the best.

Planté was the original discoverer, I think?—Yes.

Which do the defendants use? Do they use Planté's or the pasted?—They use Planté's.

The secondary batteries act as a regulator both when current is going into them and when the current is going out of them. You point out that the cells should have "a very large conducting surface." Will you tell my lord why? That is on page 4 at line 54.—I said that they should have a very large conducting surface, because the larger the surface the more readily they respond to any change in the pressure, so as to prevent it rising or falling, as it would otherwise.—The conducting surface may be increased by increasing the extent or area of the plates immersed in the liquid.

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The examination of Mr. LANE FOX by the ATTORNEY-GENERAL being continued, he said that as far as he knew, either from his then knowledge or present knowledge, there had been no publication of the use of Planté's batteries as regulators of the electric light at all.

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The ATTORNEY-GENERAL: Any publication of the use of Planté's batteries as regulators of the electric light at all?—No, there had not.

Had there been any use, or publication of the use, of secondary batteries as regulators in connection with any electric lighting at all?—No, nor, as far as I know, as regulators for keeping constant electromotive force in any shape or form whatever or electric pressure.

Mr. JUSTICE A. L. SMITH: Do I understand you to say that, prior to your patent, an electric light was always a variable light?—Yes.

The ATTORNEY-GENERAL: Your lordship has anticipated my next question, if I may put it in the form of a question; but perhaps you will take that first. Prior to your specification had anybody ever pointed out, to your knowledge, the necessity of maintaining a constant pressure with a varying light?—No, no one had.

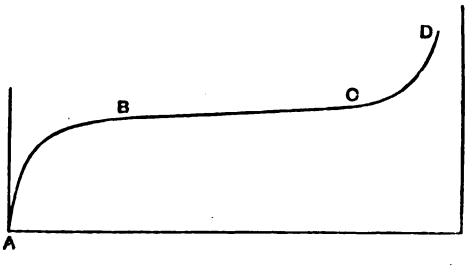
Now you point out the importance of putting several batteries at various points of the system. Do you know whether the Kensington and Knightsbridge Company, the defendants, have secondary batteries both at the stations and also at other places?—Yes, at both the station and a distance from the station. I believe it is somewhere in the neighbourhood of Queen's Gate.

Would you mind drawing in your own way a rough indication of the curve which is made of the pressure when you are charging secondary batteries to the full? Never mind if it is proportionately right, but draw a rough curve starting from half supply, or whenever you begin to charge, and then draw up to the full charging.—Charging with a fixed constant current?

Yes, charging with a fixed constant current.—It depends very much on that.

Sir HORACE DAVEY: They do not do that, I think.

The ATTORNEY-GENERAL: Well, I am not clear on that, but we will take it charging with a fixed constant current. Will you put A at the bottom, where you begin, B at the shoulder, the next point, and C where it begins to turn up, and D at the top?



The ATTORNEY-GENERAL: That shows the pressure rising from A right up to D?—Quite so.

What about would the pressure be when the pressure had fallen to the point C in your diagram?—About 2·1.

Now, at the point which you have indicated roughly as the point B, what would the pressure be, that is far away to the left?—Approximately 2 volts.

How much longer would it take to fall from C to B than from D to C?—Six or seven times. For ordinary working it would be kept between B and C.

As I will call it, on the plateau?—Yes.

Mr. JUSTICE A. L. SMITH: You mean they would be kept charged?—Yes, between these points. The closer the margin the more economical the working. The less variation, which implies waste of energy, the more economical it is. It is considered empty at B.

The ATTORNEY-GENERAL: Now, was this fact that there was at the beginning of charging this steep rise, then the plateau, and then at the end the sudden rise, perfectly well known?—Yes, it was described by Planté.

Now, if the batteries were worked in the way described, that is to say, excess current put into them during the hours of little draft to feed the mains during the hours of what I may call extra draft, would those batteries ever get off what you have called the plateau?—They would not. No.

If your direction was disregarded, namely, that the cells would not have a very large conducting surface, would it then be possible that the batteries would be too small and would not give a sufficient supply?—Quite so, the curve would slant more.

Quite so. And between the points B and C, assuming the generators to be working and the batteries working between B and C, would that or would it not keep the pressure at the lamps constant?—It would keep the pressure practically constant.

WITNESS then described the temporary lighting of Lady Conyers' house, 108, Queen's-gate, in the spring of 1882. Batteries were lent by Mr. Sellon. Lane Fox lamps were used, a steam engine was placed in an empty shop, and wires were carried over the tops of the houses. The lighting of the Brush offices at Belvedere-road, Lambeth, was carried out on the Lane Fox system in 1882: a dynamo, steam engine, and E.P.S. batteries were used, but no electrical governor. Uninsulated returns were used. There was no change or alteration in that installation in consequence of any failure of the system to maintain a constant pressure. Between 1882 and 1885 the then pasted plates of the batteries were giving a great deal of trouble, owing to the peroxide of lead which had been mechanically fastened to the plates becoming loose and dropping off. It was due to bungling—stupid workmen. Since then those pasted batteries have been largely improved and discarded. Witness then described an installation for the lighting of the Imperial Opera House in Vienna in 1883, and alluded to another which has been exceedingly successful at the King of Roumania's Palace at Senar, near Bucharest, in the Carpathian Mountains.

What companies in London are now adopting that system which is described in your patent?—The defendants', the Kensington and Knightsbridge Electric Lighting Company, the Westminster Electric Lighting Company, which is in combination—there is a trade association combined to fight this patent—the Notting Hill, the Metropolitan, the St. James's, and a great number of provincial companies.

What companies have taken licences?—The Edison Manchester have made an arrangement with the Brush Company when my patents were in their hands. I do not know much about that. They took a licence. There was a valuable consideration. What the valuable consideration was they would not disclose to me, because it raises a question in the agreement. It led to a compromise.

In reply to further examination, WITNESS said that he got back the patents into his own hands some two years ago. He was not in a position to enforce them until then. This action commenced in 1890. He had inspected the defendants' works. His system was being employed. They were using batteries connected up at various points with the mains, so that by increasing the electromotive force during the hours when not much electricity is being used they will become charged, and the electric force will be stored up in them, so that a sufficient supply will be available when the electromotive force fails, owing to the draft from the mains when the force is most used and needed; but there is just the fact that they do use a switch arrangement.

The ATTORNEY-GENERAL: During that time (whether it is an hour or two hours or more) that the number of cells remains switched in, is the operation the same as in your patent?—Exactly. The regulation goes on exactly the same.

After they switched out a number and there is a less number, does your patent describe the operation exactly with a less number of cells?—Exactly; it could not do otherwise.

What is the object of switching in and switching out cells?—The object of switching in is to make a battery of small capacity do the work of a battery of large capacity by wasting a certain amount of energy. If they had a larger amount of surface area in each cell, or a larger number of cells, it would not be necessary to switch in and switch out so often. With the battery they use the variations of the potential would be greater unless they switched cells in and out. It is not a necessity. It is a matter of expediency. The cells are called the Crompton Howell, and they are very good cells indeed. They are practically Planté cells with such modifications in detail as the exigencies of manufacture suggest.

The remainder of the examination in chief related to the patents of Achard and Clark.

In cross-examination, Sir HORACE DAVEY asked whether, in 1878, Mr. Lane Fox was not quite a youth, twenty years old or something like that. He replied that he was now 35; he had at that time already taken out several patents, and mentioned that he was then on the Council of the Institution of Electrical Engineers. He had been engaged in practical manufacture of electrical apparatus at his own works before 1878. He had works in Hatton-garden, and an office in the City. Questioned on Staite's patent, 11,783, of 1847, where it is said that "a good degree of intensity to use is such as would be afforded by 100 cells in a series of the usual sort employed in galvanic apparatuses," he said that this would be approximately 100 volts. But he thought that it was quite accurate to say that his specification was the first suggestion that a 100-volt current was the most suitable current for incandescent lighting. He did not say for electric lighting, but electrical distribution as described in the patent. He was not speaking vaguely of electric lighting when he made that remark.

I am not going into the merits of your lamp. It may, for aught I know to the contrary, be a most perfect lamp.—These are all my lamps in a sense. It is a matter merely of detail of construction. The principles on which all these lamps are constructed are actually enunciated in my patent.

In your patent of 1878?—In my patent of 1878.

And you claim all the lamps which we see around us at the present moment as being within your specification?—As coming within this specification. The Edison Company have acknowledged the validity of my patents, and all these lamps are now licensed under my patents—every one of them. There was an action brought in respect of infringement which was compromised. Before Mr. Justice Kay the judgment was to the effect that I had anticipated Edison in all particulars. That judgment was reversed.

I will allow you to say so. I do not think that is quite accurate; but the Court of Appeal did not take that view?—No.

Mr. JUSTICE A. L. SMITH: You say that these lamps were made by Edison's. Do I understand you aright that these lamps are now being used under licence from you?—From the Brush Company. Yes, under licence under my patents. I derive no benefit personally from them.

Sir HORACE DAVEY: The Brush Company brought an action against the Edison Company founded on several patents of yours, and that action was discontinued?—I was unable to ascertain the exact terms, but I believe the Edison Company waived their claim for damages against the Brush Company, and that was a very substantial amount. I do not remember the exact terms. I was never in Court. A royalty is paid of a farthing for every lamp manufactured by the Edison Company to the Brush Company. I had to ratify that licence. That is under a patent of 1880 for improvements, not under this patent of 1878.

In further cross-examination as to details, WITNESS said that the lamp was described in the present patent, not in detail but broadly. He admitted that the lamps used by the defendants did not contain iridium or platinum, but that was not essential, it was a matter of preference. After examination on the desirability of an electric regulator, and the use of gas and water pipes as "earth," he said that a current of 100 amperes would require an altogether unwieldy size of earth plate. They could not get one earth plate; they would have to divide it up into a great number, and these

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would have to cover a very large surface The question was how much energy they were prepared to lose in resistance, but he said that the size would be unwieldy. Over great distances there might be an advantage. The distance from the lamps to the generator being a mile, they might begin to get advantages from the use of an earth return. He should say a soil return, because he made an important distinction between a soil return and an earth return, as described in the specification. At a short distance the use of a soil return would be ridiculous ; no one would think of using such a thing.

Now I will ask you to look at your figure 5.* I daresay you are familiar with figure 5, which is intended to represent on an extremely condensed scale the whole system, is it not?—Yes. It is intended to represent the whole system in a diagrammatic fashion.

You have your generator, and the negative pole of your generator goes to "earth," does it not?—Yes.

And by this slightly circular kind of thing with "earth" written on it, did you not intend to describe the soil?—I did not ; I had not the smallest intention of describing the soil.

Is not the way in which an electrical engineer would ordinarily describe a terminal going to earth by an earth plate?—He would describe it in that way, and he would describe all earths in that way : he would represent all earths whatsoever in that manner. He would say that an insulated conductor was an equivalent of an earth return, but not identical. If an insulated conductor answered the purpose it would be included certainly in the words "the earth." There is a distinction between saying insulation is unnecessary and insulation must not be.

After considerable examination as to the use of batteries,

Mr. JUSTICE A. L. SMITH : What I understand you to say is this, that this specification meant that, as it is stored up, and as it is wanted either to increase or decrease, it is let out automatically?—Quite so, it is available there by means of the connections described.

Sir HORACE DAVEY : I understand that, but then the purpose for which you require your electricity is for the purpose of supplementing the current of the mains?—Yes, it is so. That is one purpose. The advantage of having a reserve store there in case anything happens to the engine is an obvious purpose which is additional.

The sole way in which you have used your reservoir is exactly that in which Planté intended it to be used—namely, to store up electricity, and to let the electricity flow from it when it is wanted?—Planté never contemplated the combination described in this specification.

Mr. JUSTICE A. L. SMITH : Planté never suggested an automatic letting out or taking in?—Never, my lord.

Sir HORACE DAVEY : Yes, my lord.

The WITNESS : Not the slightest.

Mr. JUSTICE A. L. SMITH : I have not seen that yet anyhow—not automatically.

Sir HORACE DAVEY : Yes.

Mr. JUSTICE A. L. SMITH : It may be so, but I cannot see anything about it.

Sir HORACE DAVEY : There is nothing in its being automatic—whether you turn off a tap automatically or not.

Mr. JUSTICE A. L. SMITH : I should say that made all the difference in the world, if you asked me, whether a thing acted by itself or whether a man must intervene and turn a tap.

Sir HORACE DAVEY : These Kensington people do not use that automatically?—Indeed they do. They turn it on and off as they want it.

Mr. JUSTICE A. L. SMITH : Who?—Planté?

Sir HORACE DAVEY : No, the Kensington people—the defendants.

Mr. JUSTICE A. L. SMITH : With their switches?

Sir HORACE DAVEY : Yes ; I say they turn it on and off as they want it. They do not use it automatically.

Mr. JUSTICE A. L. SMITH : I know ; but he gives the go-by to their switching.

Sir HORACE DAVEY : I think your lordship will find that is the point.

Mr. JUSTICE A. L. SMITH : I know what is coming perfectly well. I see the case, but I say as far as Mr. Lane Fox goes he gives the go-by to the switches and everything else.

Sir HORACE DAVEY : I know he does, but I hope before I have done to convince your lordship that without the switching——

Mr. JUSTICE A. L. SMITH : All that I said was that, in my judgment, an invention which would let out this current automatically was not identical with a storage of the current which you would have to go and put your finger on to let out. That is all I said. It would take a great deal to induce me to think that they are identical, Sir.

Sir HORACE DAVEY : Now let us go back to the point. I have had an elementary text-book put into my hands. I do not know if you will recollect it, it is a practical handbook by Sir David Salomons, Bart., Vice-President of the Institution of Electrical Engineers, published in the year 1891. It is on "Electric Light Installation and the Management of Accumulators." I find in the very first sentence in Chapter 6 this :—"Always charge the cells until they boil well." Well, they will not boil well until they are completely charged, will they?—No, he was referring particularly to the E.P.S. cells I think, which do require boiling, so to speak. They are a development which I say was a bad development for Planté purposes. It required special attention and care to keep them in order.

How do you know that this gentleman is talking of E.P.S. cells?—Because I think, if I remember rightly, he is a Director of that Company

Then your view is that you must find out by experiment when you are to cease charging. Is that so?—By observation. It would be perfectly manifest to an attendant with common sense if he was sober.

I do not know if that is meant for a joke.—I say that if he was in attendance there, and he knew what his business was, he would turn off steam when there had been enough work done.

* *The Electrician* Feb. 26th, p. 438.

I suppose you would say that Mr. Crompton was a person of intelligence, would not you?—I have had great difficulty in cramming the A.B.C. of the subject into his head. I found him very dense at one time.

You thought Mr. Crompton very dense?—At one time he was very dense and very obstinate. He said the whole thing was nonsense, and it would not work. He pooh-poohed the whole subject, and I had strong arguments with him to convince him that the thing was practical. He said the whole thing was an absurdity at one time.

After a long cross-examination on the use of batteries, Mr. LANE FOX was questioned about an installation by Mr. Crompton at the Law Courts. This was put in in 1882, and was alleged to be in accordance with the present specification.

Sir HORACE DAVEY : And Edison lamps, I think, were used?—I think they were called Swan lamps. I think they were practically the same lamps as were made here.

They were incandescent carbon lamps?—Yes.

I will not dispute with you whether they were Edison or Swan.—I might have taken an interest in that some time ago, but I do not now take the faintest.

Mr. MOULTON : At that time they were two different kinds of lamps.

Sir HORACE DAVEY : Excluding the lamps for a moment, if I have described it rightly, that was exactly your system, was it not?—Yes.

Sir H. DAVEY suggested that within the first week after the accumulators and generators were started, at one time it was found practically that when the batteries were being charged the lamps flared up, and in one instance one broke with a loud bang, and frightened the Court and the judges and everybody else ; and that when the batteries were being discharged the potential fell, and the lamps became red bars, and gradually went out?—Witness could not remember being consulted by Mr. Crompton as to what should be done.

In reply to further questions, the WITNESS stated that on October 12th, three days after the other patent, he took out a patent in which he described commutators to be used with batteries :—"So that it will not be necessary to increase the electromotive force in the mains in order to charge them, but by merely coupling two or more parts or the whole battery for 'quantity' they can be charged with a low electromotive force, and be capable of giving by an alteration of the commutators the full tension when required." The idea occurred to him afterwards, as an alternative to the process described just above, where a smaller battery would do the same work as an improvement. The St. James's Company are using batteries without altering the number of cells, and it is a far more successful installation than the Kensington and Knightsbridge. The potential there is kept much more nearly constant. At the Vienna Opera House there was an elaborate arrangement for adjusting the current by means of switches, far more elaborate than that at Kensington, but this was for producing special scenic effects. There was a similar arrangement of apparatus for switching on and off cells at the King of Roumania's installation. He invented them. Prof. Perry invented them five years afterwards, and Mr. Crompton did eight years afterwards. He invented them first.

MONDAY, FEBRUARY 29TH.

In reply to further cross-examination by Sir HORACE DAVEY, Mr. LANE FOX said that at the Opera House at Vienna there was a large number of different batteries for working circuits and producing different effects, and it may be that there were distinct batteries for working a different number of lamps, and that those batteries may have been worked quite independently, for the time being, of the dynamos. It was a very large installation, and very complicated. The work was carried out by his assistants, and he never visited the Opera House for the purpose of arranging it. The voltage in the mains was 90, but two 45-volt lamps were put together in series.

Do you know if that was so?—Probably it was so ; as a matter of fact one lamp was divided into two ; one lamp was made with two filaments instead of one.

At Lady Conyers' it was a specially prepared installation for that particular night?—Yes ; not specially prepared for that night ; it was specially installed for that night. There were no special requirements to suit the occasion. It was a very different case from the Opera House. The batteries were sent up to Queen's Gate ready charged, but they continued charging them after they had been set down.

You had to supplement the charge, but they were charged?—They happened to be charged batteries that were sent up. The process of charging and discharging continued during the whole of the installation, more or less ; it depended on the pressure of the steam engine and the number of lamps. He had no measuring instruments, but estimated the quantity of current. The pressure gauge of the engine gave a very good indication of what the dynamos were doing. The instrument for indicating the potential was the brilliancy of the lamps ; those are to me a very exact indication.

I ought to put this accurately, or you will be down upon me. Was your steam engine of sufficient horse-power to make the dynamos produce a current sufficient to light them?—The engine could have developed sufficient power. Did it?—Not during the whole time.

What was the voltage on that occasion?—I cannot say exactly ; it depends on the lamps we had available.

That is quite true, but cannot you tell me whether it was 100 or anything like 100?—I think it was 75, but I cannot be certain.

Mr. JUSTICE A. L. SMITH : I think you told me how many lamps you had going, but I do not remember.—I think about 50.

The ATTORNEY-GENERAL : Yes ; he stated it in chief. Might I, as there is a break, give your lordship the specification as I promised it, showing what was cut out in blue in the first one, and what was cut out in red in the second? [*Handing it in.*]

Mr. JUSTICE A. L. SMITH : He strikes out generally the lamp and the engine regulator.

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Questioned by Sir HORACE DAVEY as to his connection with the Brush Company, Mr. Lane Fox said that he filled different capacities from 1881 to 1889, and different agreements took place between them at different times. At first he was manager of what they called the Lane Fox department. It was a department specially devoted to incandescent lighting as opposed to arc lighting. He did not know whether batteries were introduced later or introduced at once in the installation at the offices, he could not be sure.

And after the accumulators were introduced was it found necessary, in order to make the installation work, to add switches and other devices for regulating the cells?—That I altogether deny: "found necessary" is an improper expression.

Now, the Brush Company was a wealthy, powerful corporation, was it not?—Yes.

And if I may draw upon my own experience, they were not afraid of litigation?—Well, I rather think they were.

Can you tell me how it is that you, having charge of the Lane Fox department, did not push this patent of yours of 1878?—I did, but the pressure against which I had to push was tremendously powerful.

The electro-motive force was too much?—There was a very strong opposing influence, due to causes which I will relate, if necessary.

Is that the only reason you can give me for this patent not having been apparently brought into use?—It is *the* reason.

It is this reason why the patent was not apparently brought into practical use?—It was brought into practical use, but my merit and my rights in the matter were successfully suppressed.

Do you suggest by the Brush Directors?—I would rather not go into invidious matters if it is not necessary. A certain sum of money, £5,000 in fact, was paid to the British Electric Light Company for foregoing a certain claim which they had, which, though not a legal claim, was considered of sufficient importance to enable them to be very obstructive. The British Electric Company had from me certain letters which gave them claims, as they said, upon my patents. No cash whatever, apart from that sum, was paid to me personally.

Mr. JUSTICE A. L. SMITH: I do not understand this. I do not know if it is necessary for me to, but £5,000 was paid to the British Electric Light Company, for what?

Sir HORACE DAVEY: They made some claims, my lord.

Mr. JUSTICE A. L. SMITH: To forego a claim, he said, not a legal one, and they got from him some letters which they said gave a claim on his patent.

The WITNESS: Yes. The whole of the £5,000 went to the British.

But nothing of that came to you?—Not a penny, my Lord. Shares were paid to me by the Brush Company—shares with a very large liability, but with a considerable amount credited as paid up.

When in practice in lighting by electricity did they begin to work these reservoirs somehow as you have described, by switches, and so on?—Not much until 1882, my Lord. The whole of my attention in the earlier days was occupied in developing the details of the lamp itself and I had no time to devote myself to that part of the system.

I understand you took out a patent for your lamp in 1878, and then worked at the lamp?—Almost exclusively.

When in electric lighting anybody other than yourself commenced to work what I may call your battery system?—No one, my Lord; I was the first to put them in practical operation.

After 1881 who began to put them into practical operation?—I began with the Electrical Power Storage Company. I was instrumental in bringing about the existence of that Company.

Tell me, for my own information, what was going on during 1883 to 1890.—The system was well started, and was worked at by a great number of individuals and companies.

Did they put up your reservoir system, I mean?—Yes, my lord.

Did you get royalties for that, or let it slide?—I did not let it slide, my Lord, but I was powerless.

Why?—Because I could not control my patents, and the Brush Company was involved in other litigation, and the whole matter is very complicated.

Sir HORACE DAVEY: Does it come to this: the Brush Company did not think it worth while, nor did they even ask for royalties?—Yes, they began an action against the Edison-Swan Company. That was the one that was compromised; but it lasted several years. There was an action exclusively on this patent against the Edison and Swan.

Mr. MOULTON: The Brush Company had divided interests.

Sir HORACE DAVEY: They commenced the ball by an action on Edison's patent?—Yes.

And this was a counterblast?—I suppose it might be regarded in that light.

And resulting in a general peace all round?—Yes.

Mr. JUSTICE A. L. SMITH: Can you tell me when that general peace came—the year?—At the end of 1889.

Sir HORACE DAVEY: It never came to trial?—It never came to trial. I was, of course, very much aggrieved at it.

But the Brush Company's advisers took a different view?—Not as to the validity of the patent; and, as you have asked me the question, I may say that General Webber, who was Managing Director of the Brush Patent Company, has stated publicly that he considered my patent as good as any they ever had anything to do with.

I think in 1881 there was an Exhibition in Paris?—Yes; I exhibited with the Brush Company for the purpose of showing incandescent light. That installation had no storage batteries. The fittings were made in London on the plan using only one insulated wire—but the French people would not have the uncovered copper wire. They insisted on having an insulated return wire. I pointed out in my patent what many would know, and some would not know, that the insulation of the return conductor was superfluous,

In incandescent electric lighting?—Yes, in incandescent electric lighting.

And you still retain that opinion?—I do, emphatically.

Now the only secondary batteries which were shown at the Paris Exhibition were by Faure, were not they, and they were shown in the ordinary manner in which storage batteries are used?—I really do not know what you mean.

For the purpose of storing up electricity and then utilising the electricity from the accumulator?

Mr. MOULTON: They were not used as regulators?—That I am not sure of. It is quite possible they were. I am not sure of their connection.

Sir HORACE DAVEY: At any rate, you had nothing to do with Faure's exhibition?—No, I had not directly, of course; the work I had done in incandescent lighting had a deal to do with it.

Mr. JUSTICE A. L. SMITH: There were no batteries?—No, not in my installation.

Did you get a constant light without the batteries?—No, we did not; it was a source of trouble.

Sir HORACE DAVEY: Now why did you not exhibit? You very properly said you wanted to push your system—this wonderful invention which the Attorney-General has described to us—at the Paris Exhibition?—As I have already told you, all my energies were taken up in producing the necessary incandescent lamps for that Exhibition.

That I quite agree with; but, remember, you had taken out this patent in the year 1878, and the Paris Electrical Exhibition was a great opportunity of introducing a new system to the electrical world.—Yes, I should have been delighted if they allowed me; but the Brush Company prevented me putting up a great deal I wanted to, and among other things they prevented me making this installation as complete as I should like.

Now, sir, will you definitely pledge your word that the Brush Directors prevented you from putting up secondary batteries in Paris?—I do not know that the matter was raised, but the matter was put in my hands, and I was limited as to funds.

The witness was then cross-examined at considerable length on the patents of Clark and Achard.

Sir HORACE DAVEY: I think you made a declaration on the disclaimer of these second disclaimer proceedings?—Yes.

And I think you admitted on Friday, when the secondary batteries were being charged there was what the Attorney-General described as a curve from rapid at first, and then more gradual, and then more rapid, you remember that?—Yes.

And I think you said that it was not right, or that any person of common sense—I do not know whether you meant any person of common sense in 1878—would not charge the batteries fully, completely?—I said, overcharge them. If you remember there was a great deal of talk as to what was "full."

No, I beg your pardon. By "full" I mean full. When I say a bucket of water is full, I mean full—not half-full.—Yes, but there is a difference between a bucket of water and a secondary battery—the analogy is very erroneous.

What I understand to be full is to the bubbling point.—Well, I do not. I call that over-full. You see it depends on the purpose for which you are using batteries. The boiling point of the batteries is an excess charge. It is necessary for forming the batteries, but it is not necessary for the purpose of storage or regulation—it wastes energy.

I will not say any fool, but any person of common sense, any electrical workman, would have known that in 1878.—No, not any electrical workman; he must have had some acquaintance with secondary batteries which he could have acquired. Telegraphists were ignorant of a great many matters connected with dynamos in 1878, yet they called themselves electricians. I quite think the word "fully" was rather an exaggeration—full for the purpose—"sufficiently" would have been a more correct expression.

You see you say "fully." Do not you think that is calculated to convey the idea to the mind of any person that what you meant was charging the batteries till they were full?—Yes, but do not you see there is a difference between us as to what "full" means?

The cross-examination of Mr. Lane Fox was continued, and questions were asked on statements made in a lecture by him at the Royal United Service Institution, and on another occasion at the then Society of Telegraph Engineers on April 14, 1881. Letters were put in by counsel, showing that the defendants had refused to allow the plaintiff to make a complete inspection of their system. The re-examination was begun on Monday afternoon, and was concluded soon after the Court sat on Tuesday. Prof. Silvanus Thompson and Prof. Barrett gave evidence on that day, and the case for the plaintiff was closed after the evidence of Prof. Forbes. Sir Horace Davey began to open his case for the defendants in the course of the afternoon, and continued throughout the sitting on Wednesday. A very elaborate model was exhibited, with the intention, apparently, of showing the great complexity of the defendants' system, as compared with the simple claim of the plaintiff. A careful abstract of the shorthand notes will be given in our next issue.

Allison v. City and South London Railway Company.

In the Chancery Division on Tuesday the case of Allison v. City and South London Railway Company again came before Mr. Justice Kekewich. This was an action brought by the surviving trustees of the Stockwell Orphanage against the defendant Company to recover damages for an alleged nuisance arising from the noise and vibration caused by the working of the defendant Company's engines and dynamos close to the girls' wing of the Orphanage. The case first came before his lordship last spring, when it was adjourned to enable the defendant Company to execute certain alterations with the view of putting an end to the nuisance.

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The defendant Company made certain alterations, which, however, did not satisfy the plaintiffs, and on the case coming before his lordship a fortnight since, he directed that Mr. Harris should visit the orphanage and the defendant Company's works, and make a report to the Court as to the true state of affairs. Mr. Harris now presented his report to the Court. It was to the effect that the defendant Company's engines did cause such a nuisance and vibration as to interfere with the enjoyment of the occupants of some of the houses at the Orphanage, and that everything had not been done to put an end to the nuisance. Mr. Harris was of opinion that it would not be unreasonable to request the Railway Company to lessen the nuisance by removing their engines to another part of the building. In answer to his Lordship, Mr. Harris said the defendant Company could place and work their engines at a distance of thirty or forty yards from any other person's property; but whether such an alteration would interfere with the satisfactory working of the railway he was not prepared to say.

Mr. COZENS HARDY, Q.C., on behalf of the defendant Company, submitted that the matter now resolved itself into a question of law. Parliament, he said, had authorised the making of the line to be worked by electricity, and although it might sometimes occasion a nuisance to persons residing in the neighbourhood of the works, the defendants were relieved from all liability unless it could be shown that they had been guilty of negligence in the manner in which they had carried on their business.

Mr. RENSHAW, Q.C., for the plaintiffs, denied that the Act authorising the construction of the line permitted the defendant Company to do that which was complained of by his clients.

His LORDSHIP, in delivering judgment, said he was of opinion that the defendant Company had now set themselves right, although they might have been wrong originally. He was bound to say that the Company had done all that could reasonably be required of them. The Company, however, would have to pay the costs of the action up to December 31st last, and he also thought they ought to pay damages, which he would fix at £50. The costs of the inspection by Mr. Harris would have to be divided between the plaintiffs and the defendants.

Freter v. Metropolitan Electric Supply Company.

In the Chancery Division, on Wednesday, Mr. Justice Chitty had before him the case of Freter v. Metropolitan Electric Supply Company (Limited), which was an action brought by Mrs. Freter, the owner of the John Gaunt Tavern, Lincoln's Inn, against defendant company to recover damages and an injunction. The plantiff's case was that the defendants' works were adjacent to her house, and that the vibration caused by the working of their machinery had damaged her property and was a nuisance. The defendants denied that the vibration was caused by the working of their engines. In the alternative they submitted that they were protected by the Electric Lighting Acts.

Mr. Byrne, Q.C., and Mr. Sebastian appeared for the plaintiff; while Mr. Lockwood, Q.C., Mr. Latham, Q.C., and Mr. Butcher represented the defendants.

After some evidence had been called, the parties effected a compromise, the terms of which were not mentioned in court.

Latimer Clark, Muirhead and Co. v. Francis.

In the Court of Appeal on Saturday last, the case of Latimer Clark, Muirhead and Co. v. Francis came before the Master of the Rolls, and Lord Justice Lopes and Lord Justice Fry, in the form of an appeal by the plaintiffs from the decision of Mr. Justice Grantham, who had entered a judgment of nonsuit.

Mr. Lawson Walton, Q.C., and Mr. Burdon appeared for the plaintiffs in support of the appeal, while Mr. Whitehouse opposed on behalf of the defendant.

Mr. LAWSON WALTON, in support of the appeal, said the action was brought by the plaintiffs, who were electrical engineers, claiming an inquiry whether the defendant, Col. Francis, had been allotted more than his proportion of founders' shares in the St. James's and Pall Mall Electric Lighting Company. At the trial before Mr. Justice Grantham, without a jury, his lordship held that the plaintiffs had disclosed no cause of action, and entered a judgment of nonsuit. The plaintiffs now appealed against that decision.

Their LORDSHIPS, without calling upon the learned counsel for the defendant, dismissed the appeal with costs.

Moorgate Street and Broad Street Building Company (Limited) v. Exchange Telegraph Company (Limited).

This case was heard in the Queen's Bench Division on Saturday last, before Mr. Justice Day.

The plaintiffs are the owners of a block of buildings known as 52 and 60, Queen Victoria-street, in the City of London; and they alleged that the defendant Company, by their servants, wrongfully affixed certain telegraphic apparatus and wires to the roof and chimneys of the buildings, and that the defendants refused to remove them when required. They claimed £100 damages. The defendants denied any wrongful entry or trespass, and stated that they obtained leave and licence from the plaintiffs or from their predecessors in title, and that they removed the wires within reasonable time. They further paid £5 into court as sufficient to satisfy any claim of the plaintiffs. Evidence was called on behalf of the plaintiff Company in order to show that it was usual to pay a rent for affixing wires. —Mr. Higgins, engineer to the defendant Company, proved having obtained leave to put the wires up from the former secretary of the plaintiff Company. It was not usual to pay a rent.

Without calling upon Mr. Shearman for the defence, his LORDSHIP said he was quite satisfied that the defendants had committed no trespass, and that they were quite within their rights. They had in their letter declined to pay damages, and asked for reasonable time to allow them to remove the wires. They were quite within their right, having obtained leave to fix them. The plaintiffs would not allow them reasonable time, but would insist upon bringing this action. The defendants had paid £5 into court, and he found that quite sufficient for the rental for the time they had occupied the roof of the premises; and he therefore gave judgment for the defendants, with costs.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February* 19, 1892.

The Thomson-Houston-Edison Consolidation.—The great topic of interest just now is the Thomson-Houston-Edison Consolidation, and about which there are divers opinions. This much is certain, that the arrangements are practically completed, although there is no formal reorganisation as yet completed. It is going on rapidly, however, and presently formal action will be taken. It seems the general impression that the Thomson-Houston Company has decidedly the best of the bargain; but this idea is probably largely owing to the fact that in the offices of the Edison Company there is considerable demoralisation, the occupants not knowing whether they are to stay or go. As a matter of fact the changes are likely to be principally in the district offices, where until now two complete working staffs have, of course, been in existence. These are now rendered unnecessary, and there is a strong likelihood that they will soon be amalgamated, dispensing with the less useful men. The businesses are so large and growing so rapidly that there is plenty of work for a very large force, and it is altogether likely that only inefficient and incompetent men will find themselves out of a job. There has been a good deal of incompetence in some departments of the Edison Company lately, and under the reorganisation steps will be taken to bring the whole force of the consolidated company into good working order.

The Buffalo Meeting of the National Electric Light Association.—The meeting of the National Electric Light Association will take place at Buffalo on Tuesday, Wednesday, and Thursday of next week, and a large attendance is promised. This present convention bids fair to be well attended and to be very business-like in character. Heretofore a good deal of energy has been wasted in elaborate and costly electrical exhibitions, and in junketing that might well be applied to furthering the common interests of the members of the Association. President Huntley, of the Association, has been active in arranging for the present convention, and to him is due very largely the credit of having made it a working convention. The Papers promised are of considerable interest and importance.

Long Distance Transmission.—At the meeting of the American Institute of Electrical Engineers last Tuesday night, an interesting Paper was read by Lieut. F. Jarvis Patten, on some conversion systems of his designing, by which the same machine could be made to give either direct, alternating, or three-phase currents in various combinations. The Paper provoked a good deal of discussion on the long-distance transmission of power, in which many interesting facts were brought out. Particularly noticeable was the belief on the part of some of the prominent members of the Institute, in the practicability of long distance transmission by continuous currents. The feeling with regard to the "Drehstrom" system appeared to be decidedly conservative.

CORRESPONDENCE.

THE MAGNETIC PROPERTIES OF OXYGEN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your number of February 19th you comment on an article by M. Guillaume in *L'Industrie Electrique* in which it is stated that oxygen possesses, in a field of medium strength, a magnetic moment per gramme twice that of iron; so that the strange conclusion would be forced upon us that oxygen is the most magnetic of substances. Now, I found (*Wied. Ann.*, Vol. XXXV., p. 163, 1888) the susceptibility of oxygen (1 atmo.,

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15°) to be $+\cdot117 \times 10^{-6}$, in good agreement with Faraday's and Becquerel's estimates. The density being ·00135, this gives a "specific susceptibility" of practically one ten-thousandth, which may just be reached with saturated alcoholic solutions of ferric chloride; such a liquid, again, could be made to rise 10cm. above its own level in a field of something like 20,000 C.-G.-S., and would doubtlessly fly at the poles if left free to do so.-

On the other hand, twice the maximum "specific magnetisation" of iron amounts to 500; for magnetite I have shown that quantity (taken singly) to be 70 C.-G.-S. per gramme. Even to reach the latter oxygen would therefore require a field of 700,000 C.-G.-S., rather over "medium strength." As no experimenter until now has reached over 30,000 (in air) nor is anybody likely to get much further, the ferro-magnetic family need hardly fear the competition of the new intruder.

None the less, a numerical determination of the susceptibility of liquid oxygen, say at boiling temperature, would be highly valuable, though probably still more difficult than causing it to splash about magnet poles, which is quite interesting enough in itself.—I am, Sir, &c., H. E. J. G. du Bois.

Physical Institute, The University, Berlin,
February 23, 1892.

Monsieur: J'ai l'honneur de vous envoyer la lettre ci-dessus, que M. du Bois a bien voulu me communiquer, pour le principe *et auditur altera pars*; je m'empresse d'ajouter que je reconnais tout le bien-fondé de son observation, la conclusion étrange à laquelle j'étais arrivé ne reposant que sur une impardonnable erreur.

Veuillez agréer, Monsieur, l'assurance de ma considération très-distinguée.

Ch. Ed. Guillaume.

ELECTRIC LIGHT CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: We have recently heard electric light cables discussed at some length, but I venture to think somewhat superficially.

There seems to me to be about as much reason for an engineer to base the breaking strain of steel on that of glass as for Mr. Preece to base the breaking strain or point of disruptive discharge of india-rubber or any other insulator on that of air.

Some of the speakers at the discussion of Mr. Preece's Paper considered it best for electrical engineers to leave the subject of electric light cables entirely in the hands of the manufacturer. For the consolation of these gentlemen I may mention that within the last few weeks I have examined samples of rubber cable made by a well-known manufacturer, and find that the pure rubber adheres neither to the wire nor to the compound rubber. The latter very much reminded me of the inferior white rubber from which cheap garden hoses are made; it was utterly devoid of elasticity, breaking short in two when stretched between the fingers; and I have no hesitation in saying that over 80 per cent. of that compound was French chalk or zinc oxide.

I am quite aware manufacturers cannot afford to give you a good rubber cable unless they are paid for it; but on reading the specification and observing the prices of these cables you do not feel inclined to place implicit faith in the manufacturer of electric light cables more than in any other manufacturer. When purchasing rubber rings or pipes, or indeed any articles made from this substance which will be subjected to a varying stress, if we wish them to be durable, we well know they must be highly elastic. Now, whether this stress is caused mechanically or electrically is immaterial; what we then require is a rubber of high elasticity, *i.e.*, of great purity.

The following are, I consider, the chief conditions to be fulfilled by a good rubber cable:—

1. The rubber must be highly elastic; this applies to both the pure and the compound rubber, although, of course, not equally.

2. The electrification of the cable under test must be great, and should at least be 35 per cent. between the first and second minutes.

3. The specific resistance should be high.

Mr. Preece tells us he does not like a rubber with too high a specific resistance; but I think all manufacturers will agree with me when I say that pure rubber should have a high specific resistance, the compound rubber depends on what is mixed with it.

It has been clearly proved that gutta-percha cable should not have a high specific resistance, and not more than 5 or 6 per cent. electrification between the first and second minutes, as both a high specific resistance and a large electrification almost invariably indicate the presence of resin; but it is most unfair to reason in the same way about rubber cable, which is a totally different article. With regard to the testing apparatus or semi-cure for rubber shown to us by Mr. Preece, in many ways it is most excellent; but whether the specimen passes this test or fails must depend to a great extent how much the rubber has been previously cured.

Great care should be taken by electrical engineers in selecting the rubber they propose to use for jointing, as these are very often the weak points in a system of mains; such rubber should be highly elastic and adhesive, to test this latter quality two pieces of the pure strip should be selected, and the two ends placed on an iron block so as to overlap one another, and then struck smartly with a hammer, when they should have firmly united. I think, Sir, you will agree with me, that since the electrical engineer now spends such a large sum of money on rubber cables, it behoves him to examine them carefully for himself, and not to take for granted all the manufacturer tells him.—Yours, &c., J. Leslie Fuller.

Hampden Club, Phœnix-street, N.W.

POWER MEASUREMENT.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have seen a report that, in a recent number of the *Atti della Regia Accademia delle Scienze di Torino*, Prof. Galileo Ferraris is credited with a statement which might mean that one of the formulæ which appear in a Paper read by me before the Physical Society of London in May, 1888, was derived from a Paper by him. If that be Signor Ferraris' meaning he is entirely mistaken. My formulæ were obtained quite independently of Signor Ferraris or of anyone else.—Yours, &c.,

Thomas H. Blakesley.

Royal Naval College, February 29, 1892.

ELECTROLYSIS OF COMMON SALT.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I find it generally not known in London and the South that the electrical decomposition of salt has for a long time engaged the attention of leading alkali manufacturers in Widnes and other places northwards; and there is evidence, from conversations I have had the opportunity of having with several electrical engineers and others in the South, that a good deal of misconception exists as to what constitutes practical alkali manufacture.

Some electrolytic processes for dealing with salt have recently appeared, and are appearing, in London; and at the conclusion of a recent notice of one erected at Battersea you wind up by saying, "Whatever the upshot of the present attempt may be, it has at least been made on a fair scale." . . . .

But I must ask, Sir, in what respect is the apparatus described to be considered as having been tried on a fair scale? If it is meant, as I believe it is, that the apparatus for electrical measurements is tried on a fair scale, then the value of your opinion in this respect is properly defined. By some people, ignorant of chemical manufactures, it may be taken to mean that the process for manufacturing caustic soda and bleach commercially was tried on a fair scale. This meaning, however, it cannot be made to convey, because you previously state a weak point in regard to the rate of production in relation to the bulky and expensive plant.

My excuse, therefore, for troubling you is to remove any probability of your opinion being wrongly construed, as obviously it is not meant to imply, as some of my non-chemical friends have considered it does, that the electrolysis of common salt has yet been proved successful on a commercial scale of manufacture. In the North we do not consider any alkali process properly tried commercially unless the plant be capable of turning out at least five to ten tons a week.—Yours, &c.,

Dundee, March 1, 1892. Northerner.

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—The Corporation of Walsall invite tenders for constructing, supplying, and laying down the necessary plant, machinery, and apparatus for lighting part of the borough by electricity. Further particulars will be found in our advertisement columns, and full information can be obtained on payment of £1 (which will be returned on receipt of a *bonâ fide* tender) to Mr. John R. Cooper, town clerk, Borough Offices, Walsall. Tenders must be sent in before Saturday, April 9th.

——— The Glasgow Corporation invite tenders for (1) the mason work and excavation, &c., works, and (2) the iron work, required in the construction of a central electric lighting station at the corner of Waterloo-street and Mains-street. Plans and specification may be seen and forms of schedule obtained on application at the Gas Office, 45, John-street; and tenders, addressed to the Committee of the Town Council on Gas Supply and Electric Lighting, must be lodged with Sir J. D. Marwick, Town Clerk, City Chambers, on or before Tuesday next.

——— The civil authorities of the town of Louvain are asking for tenders, by May 1 next, for the electric lighting of the Rue de la Station, the Place de la Station, the Grande Place, and the Theatre.—— Tenders are also being invited for the electric lighting of the military establishment at Briançon, France.

——— The Director-General of Communications in Spain is inviting tenders for 85 tons (metrical) of copper wire, 3mm. diameter, and 20,000 insulators. Tenders should reach the office of the Director of Communications, Calle de Carretas 10, Madrid, by the 14th inst.

THE E.C.C. DRY CELL.—The Electrical Power Storage Company (Limited) announce that they have appointed the General Electric Company (Limited) the sole licensees for the sale of this cell, which is being largely used on account of its suitability for telephonic and other electrical purposes.

THE SUNBEAM LAMP.—The following notice is issued to their customers by the Sunbeam Lamp Company:—"We much regret to have to inform you, that owing to action taken by the Edison and Swan Company, we shall be unable, during the continuance of the Edison patent, to meet any more of your valued orders for Sunbeam lamps. We have consented, rather than enter into a costly litigation with the Edison and Swan Company, and in view of the early expiry of both their patents, to suspend their manufacture."

MESSRS. MAVOR AND COULSON.—This firm announce that the sale to the Glasgow Corporation of the electric supply stations does not in any way affect their general business of manufacturing and contracting electrical engineers, which will be carried on as hitherto.

THE BOY MESSENGERS AND ELECTRICAL CALL COMPANY (LIMITED) notify their subscribers that, owing to the action of the Post Office in enforcing the payment of a tax of one penny on every letter carried by the Boy Messengers, they are compelled to make this additional charge of one penny on all letters so carried, the alteration to come into effect on March 7th. All messages, &c., not subject to the Post Office tax will, of course, be carried at the old tariff.

MESSRS. TRACKSON BROTHERS.—This firm write us from Brisbane that they have recently installed the electric light in the far West at Thargomindah, where kerosine frequently commands from 50s. to 60s. per case, and coal £12 per ton. Thargomindah can boast of being the first town in Queensland that has adopted the electric light. "Firth" dynamos of the latest type have been used, for which 96 per cent. efficiency is claimed. The machines have been built with special reference to the heat prevailing in the district where the installation has been made. Incandescent lamps, ranging from 16 to 500 c.p., have been used. A Robey engine has also been supplied for the plant, which will be used in the daytime for pumping, driving fans, &c. We understand that Messrs. Trackson Bros. have other similar contracts in hand.

THE P. AND O. STEAMER "HIMALAYA."—The electric light on this new steamer, launched at Greenock on Saturday, is supplied by Messrs. Siemens Brothers (Limited), and the electric bells have been fitted by Mr. C. E. Zimdars.

PRIESTMAN OIL ENGINE.—Messrs. Priestman Brothers are issuing a reprint of an interesting article on their oil engines, by Prof. W. Robinson, from the *Engineer*, with some additional illustrations, showing the various uses to which their engines are now being regularly adapted.

TRADE MARKS IN JAPAN.—Mr. A. C. Bickley writes to the papers that the Japanese authorities inform the society of which Mr. Bickley is general manager, that so long as British subjects in Japan require their cases tried in the Consular Courts so long will the Japanese Government refuse to allow protection to British patents, trade marks, or designs. Forgery of these trade marks and designs is very common in Japan, and Mr. Bickley states that they are the cause of enormous injury to British trading interests.

THE ELECTRIC APPARATUS COMPANY.—The dividends in the liquidation of this Company have now, we understand, been paid, and the Company is to be shortly dissolved.

ATLAS ELECTRIC APPLIANCES COMPANY, LIMITED (IN LIQUIDATION).—A meeting is to be held at the liquidator's on April 1st, at 3 p.m., to receive a report of the winding up.

BRITISH MEKARSKI IMPROVED AIR ENGINE COMPANY, LIMITED (IN LIQUIDATION).—A meeting is to be held at Mr. C. D. Woolley's, 1, Great Winchester-street, E.C., on April 7th, at 2:30 p.m., to receive an account of the winding-up.

FISCHER ELECTRO AMALGAMATOR COMPANY, LIMITED (IN LIQUIDATION).—A meeting will be held at Messrs. Ford, Rhodes, and Ford's, 23, College-hill, Cannon-street, E.C., on April 5th, at 12, to receive a report as to winding up.

PRETORIA.—A successful installation of the electric light was made recently at Pretoria by Mr. Van Zwieten, the local agent for Messrs. Woodhouse and Rawson United (Limited), on the occasion of a Horticultural Show.

COMPANIES' MEETINGS & REPORTS.

Electric Construction Corporation (Limited).

A general meeting of the holders of the founders' shares of the above-named Company was held at Worcester House, Walbrook, yesterday, for the purpose of considering, and, if thought fit, passing the following resolutions:—

"1. *That the capital of the Company be increased to £750,000 by the creation of 25,000 new shares of £10 each, numbered 50,001 to 75,000 inclusive.*

"2. *That the whole or any part of the said 25,000 new shares of the Company may be issued with any such rights of preference over the founders' shares, whether in respect of dividend (not exceeding a cumulative preferential dividend at the rate of 7 per cent. per annum upon the amounts credited as paid thereon), or in respect of repayment of capital or both, and with such right of voting, and generally upon such terms and conditions in all respects as the Company may from time to time by special resolution determine.*

The notice calling the meeting stated—

"I am happy to inform you that, owing to large and valuable contracts and orders obtained since the last general meeting and in immediate prospect, the Directors consider the time has arrived when additional capital can be employed to great advantage in extending the business of the Corporation, and materially increasing its profits."

Mr. SPENCER BALFOUR, M.P., presided.

Mr. W. SAMSON (the Secretary) read the notice calling the meeting.

The CHAIRMAN: Gentlemen: You are aware of the circumstances and conditions of this meeting. It is not a general meeting of the shareholders of the Company—that is to be held a little later; but this meeting is a meeting of founders' shareholders—holders of founders' shares; and under the terms of the Memorandum and Articles of Association they have to be consulted in any step that we propose to take in the increase of the capital of the Company. The reasons for that increase are stated in the circular which has been sent round to our shareholders; and I am glad to say that since our last general meeting—which I think we shall all agree was of a satisfactory character—and since the publication of the report and accounts—which also I think you will concur with me were of a satisfactory character—the business of the Company has very very largely increased indeed. There is, without wishing to say anything in terms of exaggeration, something like a "spurt" or "boom" in the way of orders for very heavy electrical plant. Now, as I stated, gentlemen, at the last meeting, the capital of the Company is already fully employed; and I am informed by Mr. Parker, our very able and successful works manager, that at the present moment we have in hand work at the actual moment equal to at least half of the whole of last year's work. We have that in hand at the present moment ——

Mr. PARKER (interrupting): Mr. Chairman, I think that is hardly a sufficient statement; if you will allow me to correct you. The orders we have in hand to-day, and what we have already delivered this year, are more than twice what we did in the whole of last year.

The CHAIRMAN, continuing, said: I am very glad to hear that. My business is not to exaggerate, but rather to under-estimate our prospects; and I am very glad indeed to have that correction from Mr. Parker; but taking it at that modest statement that I have put forward, our work in hand to-day equals the whole of the work which we had in hand in the six months of last year. You will see, therefore, that additional capital can be employed to very great advantage; and we therefore propose to ask the founders—I shall confine myself to the founders' point of view at this meeting—we shall ask the founders to concur in a resolution authorizing the additional capital. This is strictly within the terms of the original prospectus. In the prospectus issued we stated that as the business of the Company increased so we should come to the shareholders for additional capital. Well, the business of the Company has increased and is increasing; and in

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addition to the large orders that we have in hand, and in addition to what Mr. Parker has said, we have before us at the present moment very large and very paying orders, involving, of course, a considerable outlay in the first instance in wages and for machinery; but yielding, as we believe they will, very large and very considerable profits to the Company. I am sure that I am speaking the unanimous opinion of the Board when I say that never since the Company has been established were its prospects anything like so flourishing or so promising as they are to-day. We all take heart at the present condition of the Company, and we believe that the founders themselves will be largely benefited—I am speaking to the founders now, and not to the ordinary shareholders. We believe that the founders themselves will be largely benefited by this increase of capital, because if, as is probable, we shall issue a portion of these shares at a fixed preferential rate below the rate at which the ordinary shareholders will be entitled to participate in dividend, prior to the founders. that must be to the advantage of the founders. I am a holder myself of founders' shares—no less than five founders' shares—and the Board also are large holders of founders' shares. We have had several questions asked us, and the explanations which we have given have been deemed satisfactory, and I trust we shall have the unanimous approval of the founders of this step. If so, and the promises we now have before us are fulfilled—which I have every reason to believe they will be—then the founders' shares in this Company will prove a very valuable investment indeed. I beg to move the resolutions of which you have had notice. I may, however, here anticipate a question which may be put hereafter as to how we propose to raise this additional capital. Of course, we do not propose to issue the £250,000 of additional capital at once. That is not in contemplation, but it is not worth while to incur the expense of continually holding meetings for the purpose of raising additional capital. We propose to get powers to go up to £250,000 new shares, but probably we shall be content with considerably less than that. In the first instance I look to an issue of about £50,000, or, at the outside, £100,000, which is quite sufficient for our purposes at present. Then, when we have proved the success of these orders, and brought the Company into a still more prosperous condition than it is to-day, then we shall probably raise the remainder, perhaps some of it as ordinary shares, and give the founders and ordinary shareholders the right to take it up at par, or in any other way as may seem fit to the shareholders. In the first instance we shall take powers to raise the £250,000, but we have no idea whatever of certainly exceeding the £100,000.

Sir DANIEL COOPER seconded the motion, and said he, too, was a holder of founders' shares—five founders' shares—and he was also a considerable shareholder in ordinary shares, and he would not support the proposal unless he was firmly convinced that it was necessary for the Company to get additional capital if they wished to be in a successful state—that was to say, the state that they anticipated when they formed the Company; and unless they got some extra capital in the way they asked now, then the business would not thrive in the way that it ought to thrive. He hoped that the founders would unanimously consent to this resolution.

The CHAIRMAN invited discussion.

No questions were asked.

The CHAIRMAN then put the resolution to the meeting, and it was carried unanimously.

The CHAIRMAN: I am sure, gentlemen, the founders have taken a very wise step in respect to their own interests. It is necessary that the resolutions should be signed by three-fourths of those present, so the solicitor states, in conformity with the articles.

The shareholders then signed the resolution, and the proceedings closed with a vote of thanks to the Chairman.

An extraordinary general meeting of the shareholders of this Company was held at Worcester House, Walbrook, immediately after the founders' shareholders meeting, for the purpose of considering and, if thought fit, passing the following resolution as a special resolution:—

"*That the capital of the Company be increased to £750,000 by the creation of 25,000 new shares of £10 each, numbered 50,001 to 75,000 inclusive.*"

Mr. SPENCER BALFOUR, M.P., again presided.

The Secretary (Mr. W. Samson) read the notice calling the meeting.

The CHAIRMAN: Gentlemen, you have heard the notice convening the meeting read, and I will now move the resolution. The reasons for the proposal, I believe, have been expressed to you in the circular which was issued at the same time that this notice was sent out, announcing to you its objects. And to that circular I have only a few words to add. The proposed increase of capital is entirely the result of the increased progress and prosperity of the Corporation, which, I am happy to say, to-day is in a sounder and stronger position as regards its finances and as regards its orders than it has been since its establishment. The people who will probably be most affected by the increase of capital will be doubtless the founders—the holders of the founders' shares; and I am pleased to be able to tell you that at the extraordinary meeting of the founders' shareholders held to-day a resolution agreeing to the increase of capital was passed by them unanimously. I ought to mention, gentlemen, that being anxious to be able to justify, in every sense of the term, the proposal of the Board, I communicated with the manager—the very able and very successful works manager of the Corporation—Mr. Parker, because I desired to be able to state accurately to you, on his authority, the exact position of the orders which we are receiving to-day. As I said at the founders' meeting, so I can say here. There seems to be something, if not a "boom," at all events a considerable "spurt" in electrical business at the present moment. Our works—our very large and new works at Wolverhampton, which are stated to be the best works of the kind in the country—which last year were by no means in full work—are at the present moment working as hard as possible and are fully occupied; and the work which we are doing and have done during the past five months of the present financial year, on orders in course of execution or actually executed, are fully one and a-half times the total orders that we turned out last year. That is to say, in the first five months of this year the work executed and in hand amounted to something like £180,000.

Mr. PARKER: £187,000.

The CHAIRMAN: £187,000, against about £130,000 for the whole of last year. Well, such an expansion as that in the business of the Company you will all know, as men of business, necessitates an increase of the capital of the Corporation, because we of course are some weeks, and in some cases some months, out of our money—wages have to be paid regularly every week; large orders have to be given for materials, and the greater we increase our capacity for paying cash and dealing promptly with these orders the better and larger are the profits we are able to make for the Corporation. I do not know, gentlemen, that I need occupy your time longer than possible on the further increase of capital, I will only go on to mention that this has been in contemplation—it has not been "sprung" upon you. It was contemplated in the original prospectus that a much larger capital would be required, and the Directors pledged themselves that as the work proceeded so they would offer additional capital—they would propose to issue additional capital, and offer it in the first instance (as we shall do certainly)—to the existing shareholders. Now, as regards the additional capital the Board are not yet committed to any plan for raising it, and it is not in contemplation, for one thing, that we should raise the whole £250,000 directly. We propose to take powers to go up to that amount. No one suggests for one moment that we want the whole £250,000. At the present moment £50,000 or £60,000 could be employed to very great advantage. The rest would be employed later on as we make further progress. The mode of the issue of the capital the Board have not yet determined upon. The first step is to get authority to increase the capital; but no step will be taken as to the mode in which the capital is to be raised without calling the shareholders together to get their consent to the mode proposed by special resolution. The Board are very anxious to take the shareholders into their confidence, to walk side by side with you, and to have your full support and concurrence in any step which must be taken. We are advised that the first course is to get the power to increase the capital; and as to the mode in which that capital is to be issued, we shall call the shareholders together and get their consent as to what is required. I do not think I need trouble you any more. I shall be very glad to answer any questions that may be put to me. I may add, however, in addition to these very large orders I have mentioned, and this enormous increase of business—profitable business—that we are doing to-day, we have in view two or three very big orders indeed; bigger indeed than any orders we have yet undertaken. So the prospects of the Corporation could not, I think, be more favourable, and it would be a crying shame if we were to lose this opportunity of securing this business because we have not sufficient loose working capital at our disposal. We have nothing to hide, nothing to conceal in the matter, everything is straightforward and aboveboard, and I can assure you, gentlemen, that I honestly believe, as a large shareholder myself, it will be to the advantage of us all to get the additional working capital. I move the resolution.

Mr. J. IRVING COURTENAY (Vice-Chairman) seconded the motion.

Dr. DRYSDALE: Might we ask as to whether you have any idea as to the way this capital will be issued?

The CHAIRMAN: I do not quite understand your question.

Dr. DRYSDALE: What is the proposition?

Another SHAREHOLDER: Is it to be in the way of ordinary or preference shares?

The CHAIRMAN: I have already stated that the one proposition before this meeting is the formal and merely legal proposition to increase the capital of the Corporation. As to whether this increase should be by way of preference or ordinary shares, and as to how much shall be paid up, that is entirely a matter for the future. The Board have not committed themselves to any view on the subject at the present time. They will come before you with a proposal at another meeting, and take you into their confidence as to the best mode of dealing with the matter.

Dr. DRYSDALE said he would like a more definite answer, if he could get it.

The CHAIRMAN: I should be very glad to tell you if I could, but I think it much better that in this matter the Board should move tentatively. One of the largest shareholders has proposed, and has strongly urged upon us to issue the whole of the additional capital, and to call it up over a period of several years, offering it *pari passu* to all the shareholders. Another mode is that we shall make smaller issues as the business requires: that is another matter. We shall consider every method on its own merits, and we shall recommend to the shareholders what ultimately we deem best to the advantage of the Corporation. You shall certainly have an opportunity of expressing your opinion as to our method before we adopt it.

The resolution was then put and unanimously carried.

The CHAIRMAN: I think, gentlemen, I may assure you that the Board may be looked upon to do what is right in this matter.

Mr. W. J. CARRUTHERS-WAIN: I think, Mr. Chairman, you have used the word confidence, and it is because we have confidence in the personal ability and commercial knowledge of the gentlemen of this Board that we have passed this resolution unanimously to-day. We have hopes that this confidence will be justified. The increase that the Chairman has given us of the business is very satisfactory, and the best thing I can hope is that the increase of business will lead to an increase of dividend. I propose a vote of thanks to the Chairman for presiding.

Dr. DRYSDALE seconded the motion, which was carried.

The CHAIRMAN briefly responded, and the proceedings terminated.

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Telegraph Construction and Maintenance Company (Limited).

The twenty-eighth ordinary general meeting of the members of this Company was held at the offices, Old Broad-street, on Tuesday, under the presidency of Philip Rawson, Esq , J.P.

Mr. WILLIAM SHUTER read the notice convening the meeting, and the minutes of the last meeting.

The CHAIRMAN then said: Gentlemen, I am sure you will regret very much, as we all do, that our Chairman is unable to be present to-day. He has sent us a telegram from Egypt, where he is now on his way home, saying that he regrets exceedingly that he is not able to be present to-day to congratulate you on the report and accounts which we have now to lay before you. The duty therefore devolves upon me to move the adoption of the report and accounts; but I should first ask you whether you will take them as read. In moving this resolution, I am glad to tell you that I have not much to say, because the accounts show continued prosperity, and that we have done a fair amount of work during the past year, which leaves a very satisfactory result. You will notice that the accounts for the past year show a net profit of £85,199, after charging the interest on the debentures. To this sum comes to be added £61,524 brought forward from last year, making a total of £146,724, which we have to deal with. Of that amount the interim dividend which was paid in July last absorbed £22,410, leaving £124,314 now to deal with. Of this sum the Directors propose to distribute a dividend of £1. 16s. per share, which will take £67,230, being at the rate of 15 per cent., and making, with the amount already paid, a total dividend of 20 per cent. for the year, leaving £57,084 to be carried forward to the present year. If you refer to paragraph 4 of the report you will notice that the work carried out during the year has been considerable, principally owing to the completion of contracts entered into during the year 1890—that is, the laying of the cable manufactured for the most part during the previous year. At the same time we have had some work in manufacturing new cable, and business also in connection with our Gutta-Percha Works—the home trade. I may say at once with regard to the general gutta-percha business of the Company that it is a pleasure to be able to say that it continues in a satisfactory and improving position. We mention with regret that we have lost the services of Sir Thomas Fairbairn, who for 21 years served on the Board. We have been fortunate in being able to again secure the services of a former Director of this Company in the person of Admiral Lord John Hay. He, as most of you know—perhaps all of you—having received a high official command, was obliged to resign his seat at the Board; but as a vacancy has now occurred through the lamented death of Sir Thomas Fairbairn, we were very glad to fill it by electing Lord John Hay, who is again free from service afloat. I do not think there is very much that I need occupy your time with in connection with the figures of the accounts, but I shall be very glad to answer any question which you may desire to put to me. The accounts are drawn up on the old lines, and those who have followed these figures from time to time will see that there has been no very great change. I may state, although I have already said it, that your Gutta-Percha Works are doing well and improving; and altogether the position of the Company is very satisfactory. We have a fair amount of work in hand, which will go to assist the profits of the present year, I hope. If any gentleman desires any information I shall be very happy to give it, as far as lies in my power. Meantime I move:—

"*That the report and accounts of the Directors to December 31, 1891, submitted to this meeting, be and the same are hereby received and adopted, and that a dividend of 30s. per share, in addition to the 12s. per share interest or interim dividend paid to June 30, 1891, be paid on all the shares of this Company for the year ended December 31, 1891, and that such dividend be paid free of income-tax.*"

Mr. GEORGE W. CAMPBELL: I have much pleasure in seconding that.

The CHAIRMAN: The dividend warrants will be forwarded by to-night's post.

Col. CATER asked why it was considered necessary to carry forward so large an amount as £57,000 to the next account. The Chairman had told them that the Company was in a very promising condition, and therefore he thought—and no doubt the shareholders would have the same feeling—that a substantial bonus might have been paid to them this time out of the £57,000; and they could still have carried forward a good balance to meet the next dividend, which would only amount to £22,410. The £57,000 this year, and the £61,000 last year, were very large amounts—unprecedented, he thought, in any Company—to carry forward. They far exceeded the reserve fund, which only amounted to £50,000. If it was necessary to have a large amount of money in hand, he did not see why it should not be added to the reserve fund if it was not paid to the shareholders from time to time by way of bonus. The reserve fund was, it was said, the backbone of every company, and it was not a large reserve fund that they had. Having touched on the reserve fund, he thought it would be very interesting to the shareholders if the securities in which this fund was invested were printed on the back of the report in detail, showing the interest accruing from these amounts at the end of the year, and most certainly the interest should be added to the reserve fund. They now had to swallow what was printed and given to them; but he hoped that the Directors would see their way clear, when they distributed the next dividend, to give them a bonus. Instead of dividing 12s. a share let the amount be £1. If the Directors did not like to increase the dividend, which was not always desirable, let them pay the shareholders a bonus. He was very happy indeed to hear so favourable a report, and he hoped that the Board would, therefore, be able to see their way to giving the shareholders a bonus in future, instead of carrying forward so much.

Mr. CROFT observed that he had been a shareholder for many years, and in rising now to say a few words he must not be taken to assent to what the last shareholder had said. He had been in the Company for 25 years, and he was quite contented—and he believed that the great majority of the shareholders would be contented—to leave the question of paying a bonus or putting the amount to the reserve fund in the hands of the Directors, feeling confident that they would in the future maintain the same ability and integrity which they had shown in the past in the management of the Company's affairs. He knew that it had been the policy of Mr. Rawson's predecessors in the chair—a policy which was, no doubt, found in experience to work well—to discourage any undue inquisitiveness on the part of shareholders with respect to the business of the Company. He was confident from his own experience that this had been the policy of the Directors, and he believed it to be a wise one. He was not going to ask them to depart from it in the slightest degree in the question he was about to ask. He saw that a statement was made in the House of Commons some weeks back as to the laying of a cable between the Bahamas and the mainland. He saw that this cable had been laid by—he supposed he might call it—a rival Company. He did not want the Directors to disclose any necessary secret; but he wished to ask them whether this Company had a chance of laying that cable, and whether it rested with the Directors or not to tender for the contract. He thought they would be able to answer this question without disclosing any secrets.

The CHAIRMAN: I will answer the gentleman who first spoke. I believe—although I do not know if I am quite correct—that by our Articles of Association we cannot have a reserve fund exceeding £50,000. We are tied in that matter by our Articles. I think that that answers your question in regard to that point.

Mr. SHUTER: That is the statutory reserve, the amount which we have the power of reserving for our general or other purposes.

The CHAIRMAN: The gentleman who followed Col. Cater has, I think, pretty fully answered the objection you have raised with respect to this very large sum which we carry over. If you compare this £57,000 with the sum carried forward last year, there is a diminution of a few thousand pounds; but it is necessary that this Company, if they are to take large contracts, should be in as strong a position as possible, and it would be exceedingly bad policy if we were to divide our profits up to the hilt. It has always been the policy of this Company to keep as large a reserve as they could. I think in saying this I have answered your questions. With reference to the Bahamas cable, the contract was before this Company, but it was not such a one as we thought we could accept. If any other gentleman wishes to say anything I shall be happy to hear him, but if not I will put the resolution to the meeting.

No other shareholder rising to speak,

The CHAIRMAN put the motion in the usual way, and declared it carried unanimously. Continuing, he proposed that—

"*Mr. George William Campbell be and is hereby re-elected a Director of this Company.*"

Admiral Sir GEORGE H. RICHARDS seconded the motion, which was carried unanimously.

Mr. GIBSON next proposed the re-election of Mr. John Gane, F.C.A., and Mr. Patrick A. Glegg, as auditors of the Company for the year 1892, at the usual remuneration. He trusted that the duties of these gentlemen might always be as agreeable as they had hitherto been.

Mr. CROFT seconded the motion, which was adopted.

The CHAIRMAN having intimated that that terminated the business,

Mr. CROFT said he thought that before separating the shareholders ought to pass a vote of thanks to the Chairman and the Directors for the very able way in which they had conducted the business of the Company. Considering the financial troubles which the City of London had gone through in the last 18 months it was a very great feather in the cap of the Directors that they had been able to maintain the rate of dividend which had now been continued for a great many years.

Mr. GIBSON expressed his gratification at seconding the resolution, but said he wished to include the officers in the vote. He only hoped that they would always meet under as favourable circumstances as they did at the present time. However inclined they might be to receive a higher dividend, he felt sure that they would be very sorry to see any reverse take place in the position of the Company, and the prudent lines which the Directors took seemed the best guarantee against such a contingency.

The motion was carried unanimously.

The CHAIRMAN: On behalf of the Directors and also the officers, I thank you sincerely for the very kind way in which you have spoken of our exertions and the success which they have led to; and I can assure you that nothing shall be wanting on our part to secure an equal measure of success in the future.

The meeting then separated.

City of Bath Electric Lighting and Engineering Company (Limited).

The first annual meeting of the shareholders in this Company was held at the works, Dorchester-street, Bath, on Saturday, under the presidency of Lieut-Col. Vaughton, Chairman of the Board.

The report of the Directors was as follows:—

"The Directors have pleasure in submitting the first annual report and statement of accounts. The number of shares allotted is 3,246, upon which the sum of £31,981 has been paid. The result of the first year's operations of the Company is, in the opinion of the Directors, satisfactory. During the year the supply of current for incandescent lighting increased by 50 per cent., and the current is now supplied nightly to 102 arc lamps and 5,000 glow lamps. The gross profit amounts to £1,626. 8s. 5½d., and after deducting Directors' fees, salaries, and other standing charges, there remains a net balance of £585. 19s. 1½d. The Directors recommend that a

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dividend at the rate of 4 per cent. per annum (absorbing £556. 16s.) be declared on the paid-up capital. The Directors have not written off any amount for depreciation, but all repairs and renewals have been charged to profit and loss account, and care has been taken to keep up all the plant to its original working efficiency. The engineer in chief, Mr. Olsson, reports: 'In accordance with your request, I have pleasure in informing you that the plant is in good working order. The engines and dynamos have been kept in thorough repair, and the mains, both for arc and incandescent lighting, are in perfect order.' The Directors propose, in order to meet future depreciation of machinery, and to provide for exceptional outlay in any one year, to constitute a renewals fund, to which the balance of revenue, after providing for the dividend above mentioned, will be carried. The electric light is finding increasing favour in the city, as is evidenced by the many fresh installations. Among other buildings, the Bath and County Club has been fitted throughout. Deputations from various towns have visited Bath during the past year, for the purpose of inspecting the company's works and lighting arrangements. The general testimony is that the central station is one of the most successful yet carried out, and the only improvement suggested by the deputations is that in some parts of the city additional arc lamps should be erected. The Directors anticipate that the coming year will show even better results, and they are giving special attention to the question of reducing the initial charge for installing the electric light. They are also considering the question of giving a day and night supply of electricity."

In moving the adoption of the report and statement of accounts, the CHAIRMAN said the Directors trusted that both would be satisfactory to the proprietors. There had been a very considerable increase in customers for the incandescent lighting, and since that report had been drawn up several new contracts had been entered into. At present the plant was up to double the amount of the work now required, and of course they would be very glad when even more customers would require supplies. The day and night supply had been under the consideration of the Board, but this would involve a considerable expense, and as yet it had not been settled when the matter would be carried out. It was also their intention to introduce meters in the course of the year. This would prevent any waste of current, and would place all customers upon an equal footing. By looking at the profit and loss account, they would see that the working expenses had been £4,318, while there still remained unpaid a balance of the purchase money of the undertaking amounting to £1,834. The Council had appointed Mr. Gatehouse as their inspector, and the Company would be only too glad to give him all the assistance in their power. They were able, happily, to speak very highly of their chief electrician (Mr. Olsson) and the other members of the staff. During the year they had received visits by delegates from other towns in the north of England. Their general testimony was that the installation at the central station had been most successfully carried out, and the only improvement they suggested was that in some parts of the town additional arc lamps should be erected. That, of course, rested with the city authorities.

Major-General JERVOIS seconded. He thought what they had heard from their Chairman was very satisfactory upon the whole. They knew that in the formation of a new company little difficulties were certain to arise. They had not been exempt from such, but he thought that so far they had very successfully overcome them, and he believed that soon they would receive that encouragement which they deserved. The Company promised in the future to be a great success; and he was of opinion that the citizens had every reason to be satisfied with the installation.

The report having been adopted, the auditor was re-appointed, and the meeting closed with a vote of thanks to the Chairman.

Northampton Electric Light and Power Company (Limited).

A general meeting of this Company was held at the Guildhall, Northampton, on February 25th. Mr. S. L. Seckham (Chairman of Directors) presided. The report stated that the mains already laid amounted to 2,800 yards, and that there were in use or being installed no less than 3,400 lights of eight candle-power. This, as Alderman Randall explained, was 1,400 lights in excess of anticipation. In consequence of the large increase in the business, it had become imperatively necessary to enlarge the machinery at an early date. The year's trading showed a loss of £461. 7s. 2d.; but that, it was explained, was owing to the expenses of a year's working being set against an income of only about three months. Mr. Cleaver and Mr. W. Tomes were re-elected Directors, and Mr. Hull was re-appointed auditor. Several Directors and shareholders spoke most highly of the prospects of the society.

Keswick Electric Light Company (Limited).

The annual report of the Directors of this Company states that during the past year they have experienced great difficulties in having to run the station with plant only partially supplied with water-power, in consequence of which considerable expenditure has been incurred in providing steam-power to supply the deficiency. The business of the Company continues to increase, and in order to meet the requirements it has been found necessary to make considerable extensions in the main wiring, the advantages of which to the Company are not yet fully felt. Notwithstanding these difficulties and the extraordinary working cost, the Directors have satisfaction in presenting a statement of accounts, which shows a balance upon the year's working of £87. 8s. 5d., which, being added to the balance left over from the previous year, leaves a sum of £122. 4s. They propose the payment of a dividend of £3 per cent., which will leave £44. 10s. 7d. to be carried forward to the next account. The receipts from consumers amount to £541. 11s. 2d.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of the majority of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322.]

JOHN ASTLEY AND SONS (LIMITED).—This Company was registered on the 26th February, 1892, with a capital of £3,000 in £5 shares, by Hooper and Son, 69, Ludgate-hill, London, E.C. The objects are to acquire, take over as a going concern, and carry on the business of, among other things, manufacturers of and dealers in electrical, chemical, photographic, and scientific apparatus and materials, carried on by the firm of John Astley and Sons, at 4, Broadgate, and Hales-street, Coventry.

"ELECTRICAL PLANT" (LIMITED).—The above-named Company was registered on February 27, 1892, with a capital of £10,000, in £10 shares, by Messrs. Crouch, Edwards, and Heron, 70, Basinghall-street, London, E.C. The objects are to acquire and take over as a going concern the business of the owners and proprietors of the monthly periodical known as *Electrical Plant*, now carried on at 52, Queen Victoria-street, in the City of London, by Henry Sherley Price and Wallis Rivers Goulty, and all or any of the assets and liabilities of the said owners and proprietors in connection with that business; and with a view thereto to adopt and carry into effect an agreement made between Henry Sherley Price and Wallis Rivers Goulty of the one part and the Company of the other part, to print, publish, and carry on the said periodical, either as a monthly periodical or otherwise, and either under its present or any other name; to establish, purchase, print, and publish any other newspaper, journal, magazine, periodical, or other publication in connection with the science of electricity; and generally to carry on the business of newspaper proprietors, printers, publishers, and advertising agents. The signatories to the Memorandum and Articles of Association are:—

	Shares.
Henry Sherley Price, 52, Queen Victoria-street, E.C., engineer	246
Wallis Rivers Goulty, Albert Chambers, Albert-square, Manchester, mechanical engineer	246
Ernest R. Dolby, 8, Princes-street, Westminster, consulting engineer	5
Sherley S. Price, jun., 52, Queen Victoria-street, E.C., engineer	1
Maurice Belsham, 52, Queen Victoria-street, E.C., engineer	1
W. Howard Goulty, 63, Brown-street, Manchester, solicitor	1
H. Cuthbert Hall, "Eversley," Elmfield-road, Bromley, Kent, electrical engineer	75

The number of Directors is not to be less than three nor more than seven, the first being H. S. Price, W. R. Goulty, and H. C. Hall.

"ESTON" ARC LAMP SYNDICATE (LIMITED).—This Company was registered on February 27, 1892, with a capital of £25,000, in £5 shares, by H. W. Christmas, solicitor, 42A, Bloomsbury-square, London, W.C. The objects are to carry on the business of an electric lighting company in all its branches, electricians, electrical and mechanical engineers, suppliers of electricity for the purposes of light, heat, motive power or otherwise, manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, distribution, supply, accumulation and employment of electricity and any other business which may seem to be conveniently carried on by the Company; to purchase or otherwise acquire, develop, and turn to account any inventions, letters patent, &c., and in particular to acquire the patented invention for the arc lamp called the "Eston" arc lamp; and to construct, lay down, establish fix, carry out and supply all the necessary cables, wires, lines, accumulators, installations, lamps, and works for the generation, accumulation, distribution, and supply of electricity. Unless otherwise determined by a general meeting, the number of Directors is not to be less than three nor more than six, the first being W. Wynn Westcott, M.B., George North, M.I.M.E., A.M.I.E.E., Julius A. White, and Albert Essinger. The qualification of a Director (except first Directors), 20 shares.

HIND AND LUND (LIMITED).—This Company was registered on February 26, 1892, with a capital of £10,000 in £1 shares, by Hooper and Son, 69, Ludgate-hill, London, E.C. The objects are to acquire and take over as a going concern, and carry on in all its branches, the business of ironfounders, mechanical engineers, manufacturers of machinery of every kind, toolmakers, brassfounders, metal workers, electrical engineers, &c. now carried on at Preston, Lancashire, under the style or firm of Hind and Lund. Registered office: Edward-street, Preston.

PIONEER TELEPHONE COMPANY (LIMITED).—This Company was registered on February 26, 1892, with a capital of £100,000, in £10 shares, by Messrs. Dawes and Sons, Solicitors to the Company, 9, Angel-court, London, E.C. The objects are to procure the general establishment and development of telephonic means of communication and to diminish the cost thereof, and procure the adoption of improvements therein; to negotiate for and acquire provisionally or otherwise, lands, buildings, options, contracts, goodwills, patents, concessions, licences, easements, rights, claims, and business concerns and undertakings, and to promote the floating of a telephone company or companies, with ample capital and resources, and to make over to such company or companies all or any of the premises, patents, &c., so acquired, on such terms as may be arranged, and to assist and support any such company or companies; to carry on the business of a telephone company in all its branches, and to transmit and facilitate the transmission of messages and communications by telephone, telegraph, messengers, or otherwise; and to establish, manage, control and regulate telephonic exchanges and all kinds of conveniences and facilities which may seem likely to lead to the more general use of telephonic means of communication; to construct, carry out, maintain

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improve, manage, work, control and superintend any cables, wires, lines, stations, exchanges, offices, electric works, factories, and warehouses, and to carry on the business of electrical engineers. Among the objects of the Company, not particularly alluded to in the Memorandum of Association, is included that of acquiring certain rights and interests secured to the Electric and General Investment Company (Limited) by an agreement dated January 1, 1892, under which the undertaking of the Mutual Telephone Company (Limited), in Manchester, may be acquired upon certain terms stated in the agreement. Another object is that of providing the necessary capital for the New Telephone Company (Limited), the objects of which are the acquisition, establishment, and working of telephonic exchanges throughout the United Kingdom, under licence from Her Majesty's Government, and for transferring to the said Company the rights and interests under the agreement of the 1st January, 1892, so to be acquired as above mentioned, and also certain provisional advantages in connection with "way-leaves" for telephone cables within the metropolis. The signatories to the Memorandum and Articles of Association are:—

	Shares.
Duke of Marlborough, 3, Carlton House-terrace	1
M. B. Praed, 189, Fleet-street, E.C., banker	1
J. B. Braithwaite, Jun., 18, Highbury New-park, N., stockbroker	1
F. W. Reynolds, Bromley, Kent, engineer and merchant	1
George Herring, 1, Hamilton-place, W.	1
Cecil Braithwaite, 10, Lyndhurst-Road, Hampstead, stockbroker	1
J. Cecil Bull, Broughton Lodge, Surbiton, Surrey, secretary to a public company	1

The number of Directors is not to be less than two nor more than ten, the first being the following:—The Duke of Marlborough, Colonel the Hon. Oliver Montagu, Charles Praed, and F. E. Savory. Registered office: 1 and 2 Great Winchester-street, London, E.C.

[Readers who desire more information respecting the New Telephone Company (Limited) and the Mutual Telephone Company (Limited) can refer to *The Electrician* of December 25, 1891, and to our last week's issue.]

THOMPSON, RITCHIE, AND CO. (LIMITED).—The above-named Company was registered on February 22, 1892, with a capital of £5,000, divided into 200 Five per cent. preference and 300 ordinary shares of £10 each, by Lake, Beaumont, and Lake, 10, Lincoln's Inn, London, W.C. The objects are to purchase or otherwise acquire and carry on and develop the business of electrical engineers, as now carried on by Arthur Stanley Grove at 34, Victoria-street, Westminster, London, S.W., under the style or firm of Thompson, Ritchie, and Co., and with a view thereto to enter into and carry into effect the agreement referred to in Clause 2 of the Company's Articles of Association (which is between Arthur S. Grove and the Company), and to carry on the business of electrical and general engineers, builders, decorators, iron and brass founders, carriage and waggon builders, &c. The signatories to the Memorandum and Articles of Association are:—

	Shares.
A. S. Grove, 34, Victoria-street, Westminster, S.W., electrical engineer	1 ord.
J. C. Waltham, 34, Victoria-street, Westminster, S.W., electrical engineer	100 pref. / 65 ord.
G. E. Lake, 10, Lincoln's Inn, W.C.	1 ord.
E. Waltham, 45, Christchurch-road, Streatham, S.W.	1 ord.
A. S. Giles, 34, Victoria-street, Westminster, S.W., electrical engineer	1 ord.
W. Daniel, 55, Chancery-lane, W.C.	1 ord.
C. H. Hurst, 14, Aytoun-road, Stockwell, S.W.	1 ord.

The number of Directors is not to be less than two nor more than four, the first being A. S. Grove and John C. Waltham. Qualification, 50 ordinary shares. Remuneration, £600 per annum, such amount to be divided as they themselves from time to time determine.

MISCELLANEOUS COMPANIES.—Amongst the companies recently registered whose objects have more or less connection with electricity are the following:—

Archibald Cousland & Co. (Limited); capital, £10,000.
A. Fearnhead & Co. (Limited); capital, £5,000.
British, Foreign, and Colonial Patents Syndicate (Limited); capital, £10,000.
Square Hole Boring Tools (Limited); capital, £25,000.
Oates and Green (Limited); capital, £50,000.

DURAND ELECTRIC, PETROLEUM, AND GAS ENGINE AND MANUFACTURING COMPANY (LIMITED).—In reply to letters addressed to this Company at 175, Strand, London, W.C., respecting its non-compliance with relation to the filing of returns according to statute, a letter has been received by the Registrar in which it is stated that the Company has never allotted any shares, had any shares subscribed for, or traded in any way, and should have been removed from the register. The Company was registered on March 15, 1890, with a capital of £100,000, in £5 shares, to acquire and carry on the business carried on at No. 163, Avenue Victor Hugo, at Paris, and elsewhere, by Eugene Durand, and to carry on the business of mechanical and electrical engineers, and manufacturers and dealers in electric, petroleum, gas, or other engines.

ELECTRIC TRAMWAYS CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—The annual return of the above-named Company, made up to the 13th February, 1891, was filed on February 8, 1892. The Company was registered on the 8th December, 1886, with a capital of £250,000, in £1 shares, to acquire licences to work or use any British or foreign patents or inventions capable of being used for the application of electricity as a motive power, particularly for the propulsion of tramcars or other vehicles, and to complete and carry out, with any variation or modification which the Directors might think fit, an agreement dated the 7th December, 1886 for the purchase and acquisition of certain letters patent granted to Michael Holroyd Smith, of Halifax, consulting and mechanical engineer, for "Improvements in tramways and railways, and the use of electricity as a motive power for tramcars." At the time of making up seven shares had been taken up, on which, however, no calls had been made, the original subscribers to the Memorandum and Articles of Association being the only shareholders. No agreements for the acquisition of any patents, inventions, contracts, plant, premises, &c., have as yet been filed. Registered office: Royal Insurance Buildings, Crossley-street, Halifax, Yorks.

SHEFFIELD TELEPHONE EXCHANGE AND ELECTRIC LIGHT COMPANY (LIMITED) (IN LIQUIDATION).—The following notice was filed with the other papers of the above-named Company on January 18, 1892:—"At a general meeting of the shareholders of the above-named Company, duly convened and held at the registered office of the Company, Station-road, Sheffield, on Thursday, January 14, 1892 (pursuant to Section 142 of the Companies' Acts, 1862), the following resolution was duly passed:—'That the statements of the liquidators and their report be and is hereby accepted and approved.' Dated this 14th day of January, 1892. (Signed) T. G. Shuttleworth, Wm. Johnson, liquidators." This Company was registered on September 11, 1888, with a capital of £60,000, in £10 shares, to purchase from John Tasker, of Sheffield, the goodwill of the following businesses:—The businesses of the Sheffield Telephone Exchange and the Rotherham Telephone Exchange, both in the county of York, established by the said John Tasker, and the plant, machinery, &c., used in connection with such businesses, including the licence of the Postmaster-General, to establish and carry on telephone exchanges, and to carry on the said businesses in all or any of their branches. On August 11, 1890, a notice was filed, stating that the liquidators of this Company had given their consent to the registration of a new company of the same name (which was registered on August 28, 1890, with a capital of £100,000, in £10 shares). Registered office: Station-road, Sheffield.

SIMPLEX ELECTRICAL SYNDICATE (LIMITED).—The following notice was filed with the papers of the above-named Company on February 17, 1892:—"To the Registrar of Joint Stock Companies. I have to inform you that a meeting of the Simplex Electrical Syndicate (Limited) was duly held on February 16, 1892, for the purpose of receiving an account showing the manner in which the winding up of the Company had been conducted, and the property of the Company disposed of, and that the same was done accordingly. (Signature) W. J. M. Menzies, Liquidator. Dated February 17, 1892." The above-named Company was registered on February 15, 1886, with a capital of £6,000 in £50 shares, to acquire, develop, and turn to account the following patents:—(*a*). No. 3,901, dated February 25, 1884, for improvements in electric arc lamps. (*b*). No. 15,030, dated November 14, 1885, for improvements in electric arc lamps. (*c*). No. 7,390, dated June 17, 1885, for improvements in arc lamps; and (*d*), No. 12,840, dated October 26, 1885, for improvements in secondary batteries.

CITY NOTES, &c.

ACTIEN-GESELLSCHAFT MIX AND GENEST (BERLIN).—The balance-sheet shows a gross profit on last year's working of 160,306 marks, and the Directors have declared a dividend of 6 per cent., and have written off 62,000 marks on plant and patents.

BOY MESSENGERS AND ELECTRIC CALL COMPANY (LIMITED).—A meeting of this Company was held on Tuesday at Anderton's Hotel, Fleet-street, E.C., but representatives of the press were not admitted.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended February 28th were £834, as against £754 in the corresponding period of last year, showing an increase of £80. The total receipts to date, from January 1st, 1892, are £7,061, against £6,233, an increase of £823.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of February were £3,600, as compared with £3,418 in the corresponding month of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of February amounted to £58,284, as against £59,155 in the corresponding period of last year, a decrease of £871.

EASTERN EXTENSION TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the month of February amounted to £39,002, as against £43,833 in the corresponding period of last year, a decrease of £4,831.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—Major Flood Page was on Tuesday last elected a Director of the Company, to fill the vacancy caused by the death of Mr. Leyland. Major Flood Page was also elected Deputy-Chairman of the Company.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—Mr. W. W. Duncan, in his report for March, again deals with the shares of this Company, in which he takes a very healthy interest. He strongly advises the purchase of Electric Construction shares generally and of the Electric Construction Corporation Shares in particular, in preference to Supply Companies' shares. He concludes by recommending the Directors to issue Seven per Cent. Preference shares, with a contingent profit after the ordinary shareholders had received a dividend of 10 per cent. He believes that there will be no difficulty in earning the dividends referred to. In reference to this issue of further capital we refer our readers to the report of the Corporation's meetings, held yesterday (Thursday), reported in this issue.

ELMORE'S FRENCH COPPER DEPOSITING COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee for 33,250 vendors' shares, Nos. 66,751 to 100,000, to be quoted in the Official List.

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LIVERPOOL ELECTRIC SUPPLY COMPANY (LIMITED).—The Directors recommend a dividend for the year 1891 of 4½ per cent., comparing with 3½ per cent. for 1890.

PIONEER TELEPHONE COMPANY (LIMITED).—Subscriptions have been asked this week for £75,000, in 7,500 shares of £10 each, in the above Company. The prospectus was issued by the Electric and General Investment Company (Limited), and the subscriptions opened on Tuesday last and closed yesterday (Thursday) for London and this morning (Friday) at 11 a.m. for the country. The Company is ultimately to take over the Mutual Telephone Company (Limited) in Manchester, which will form the nucleus of the new telephone combination, which is called the New Telephone Company (Limited), which latter Company has been reconstructed for the purpose of entering into competition with the National and other telephone companies in London and the provinces. The prospectus states "*the profits of this Company will largely depend upon the successful issue of the capital of the proposed New Telephone Company*," whose Bill has yet to be considered by Parliament. The Directors of the Pioneer Company include the Duke of Marlborough; the secretary is Mr. J. Cecil Bull; and the offices, 1 and 2, Great Winchester-street, London, E.C. The authorised capital of the Company is £100,000, of which the present issue forms part.

SUBMARINE CABLES TRUST (LIMITED).—On and after the 15th inst. the coupon due in October last will be paid in full by Messrs. Glyn, Mills and Co. The coupons should be left with the bankers for examination four clear days before payment.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. Feb. 24		Price Wednesday, March 2.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending March 2.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,800,980	Stock	16 0	Anglo-American	49	50	49	50	5 5 0	Jan., Apr., July, Oct	..	..
£2,849,510	Stock	3 0	Do. Preferred	88	89	88	89	5 18 0	" "	89	88
£2,849,510	Stock	5/0	Do. Deferred	11¾	12¼	11¾	12¼	..	" "	12⅛	12
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99	102	99	102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	10¾	11¼	10¾	11¼	7 2 3	Mar., June, Oct., Dec.	11 1/16	11
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 5	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	153	157	152	157	4 9 2	Jan., Apr., July, Oct.	154½	..
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	16	17	16½	17½	5 14 3	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3¼	3⅝	3¼	3⅝	6 18 8	April and October	..	..
6,000	5	10%	Do. Preference 10%	8¼	9½	8½	9½	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11	11½	11	11½	6 5 0	Jan., Apr., July, Oct.	11½	11
400,000	10	2 6	Eastern	14⅝	14¾	14⅝	14¾	4 7 5	" "	14¼	14⅛
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15 1/16	15
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107	110	107	110	3 12 9	May and November	108½	108
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	105	109	105	108	4 12 7	February & August	..	..
250,000	10	2/6	Eastern Extension	14¼	15⅛	14¼	15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	14⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	106	109	106	109	3 13 5	February & August	107½	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102	105	102	105	4 15 3	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	101	104	101	104	4 16 2	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99	102	99	102	3 18 5	February & August	101	100½
180,227	10	1 6	Globe Telegraph and Trust	9¾	10¼	9¾	10¼	5 6 2	Jan., Apr., July, Oct	10 1/16	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	14¾	15¼	14¾	15¼	3 19 10	" "	15 1/16	14⅞
150,000	10	5/0	Great Northern	18⅝	19¼	18⅝	19¼	4 8 4	Jan., April, and July	18¼	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883 xd	106	109	105	108	4 12 7	March & September	107	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	42½	..
38,348	10	4 0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures xd	106	109	103	106	5 13 2	March & September	..	..
9,000	8	4/0	Reuter's	7¼	8	7¼	8	5 3 2	April and October	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	115	120	116	121	4 19 2	" "	117½	..
15,609	10	8/0	West African Telegraph	7	8	7	8	6 5 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures xd	101	104	99	102	4 18 0	March & September	102¾	..
30,000	10	2 0	West Coast of America	4	5	4	5	..	January and July	4⅛	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	102½	..
88,321	10	1 0	West India and Panama	1⅛	1⅜	1⅛	1⅜	..	" "	1⅛	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	9¼	10½	9¼	10½	5 17 1	May and November	9¾	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8¾	9¼	8¾	9¼	6 6 4	" "	..	..
67,007	15	6/0	Western and Brazilian	10¼	10¾	10	10½	7 2 10	" "	10⅜	10 1/16
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6¼	6¾	6	6½	5 15 7	" "	6⅝	6½
30,361	7½	7/6	Do. 5 per Cent. Deferred	4	4½	3¾	4¼	..	" "	4 3/16	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	101	104	101	104	5 15 5	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	101	104	101	104	5 15 5	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£178,100	£100	6%	Do, 6 per Cent. Sterling Bonds xd	98	102	97	100	6 0 0	March & September	..	..
			TELEPHONES.								
£24,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜	½	⅜	½	8 7 7	May and November	.	..
£20,000	£1	4·76d.	Oriental (11s. paid)	¼	⅜	¼	⅜	6 8 11	Yearly		..
438,984	5	2/6	National	4⅛	4⅝	4⅛	4⅝	6 17 2	June and December		4½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13	13½	13	13½	4 8 11	" "	15	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	11½	12½	11½	12½	4 16 0	" "	12	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	104	107	104	107	4 4 1	January and July	..	..
58,000	5	1/0	United River Plate	1	2	1	2		" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	80	90	80	90	5 11 1	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£6 paid)	6½	6¾	8	8½	..	—	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
6,332	£5	..	House to House Electric	5¼	5⅜	4½	5	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5¾	6¼	5¾	6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5¾	6¼	5½	6	..	January and July	..	..
30,000	£5	3½%	Liverpool Electric Supply (£3 paid)	2⅜	2¾	2⅜	2¾	..	March	..	..
10,000	£5	3½%	Do. (fully paid)	4⅜	5	4⅜	5	..	March	..	..
111,000	5	..	London Electric Supply	⅞	1⅛	⅞	1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8¾	8¾	8¾	9	..	..	9	8¾
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½	5¼	4½	5¼	—	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8¼	8¾	8¼	8¾	—	..	8¼	..
7,900	£5	7%	Do. 7% Preference	7¼	7¾	7¼	7¾	..	..	7⅛	..
42,853	5	..	Westminster Electric Supply (fully paid)	5¾	6¼	6	6½	..	..	6⅜	6⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1 8	Brush Electrical Engineering	3⅛	3⅜	3¼	3⅜	..	..	3 1/16	3⅛
69,996	2	6%	Do. 6 per Cent. Preference	2	2¼	2	2¼	5 7 7	..	2⅛	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼	6	5¼	6	5 16 8	January and July	5⅛	5⅛
17,189	5	17½	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	12/0	Electric Construction	5⅛	6	5½	6½	..	—	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	3	3½	2⅝	3½	..	—	6	5⅛
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	—	3 1/16	3
41,600	10	15/0	India Rubber, Gutta Percha & Telegraph Works	21	22	21	22	4 10 11	February & August	..	..
£300,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	106	103	105	4 5 9	March & September	21¼	20½
11,334	£10	6/4	International Okonite Limited Ordinary	3½	4½	3½	4½	..	..	..	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 18 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	1/16	1/8	1/16	1/8	..	..	..	..
78,939	5	5/7½	Swan United (£3. 10s. paid)	4	4¼	4	4¼	8 11 10	May and November	4¼	4¼
86,250	12	12/0	Telegraph Construction and Maintenance	45	47	45	47	5 2 7	March and July	46½	45½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	⅞	1⅛	⅞	1	6 0 0	..	..	..
—	£5	8%	Do. Preference (fully paid)	3	3½	2¼	2¾	11 0 0	—	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
60,000	£10	—	City and South London Railway	2⅛	3⅛	2⅛	3⅛	..	—	..	..

* xd and bonus.

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NOTES.

A remarkable example of an invention, which was made several years too soon, is afforded by the oil insulation of Prof. Hughes. It was appreciated by very few people at the time, and practically adopted by none; it was put on one side by the inventor, who busied himself with other work; it was patented by another inventor fifteen years later; and now, after a period of thirty-three years, its value is becoming recognised. It might have found many useful applications within the fourteen years of the patent, but it is only with the introduction of high voltages that the real utility will be appreciated

Whatever the Electrical Exhibition at the Crystal Palace may have failed to do, it has certainly succeeded in fulfilling our anticipation that it would prove a great attraction to Town Councillors and others interested in municipal improvements. Hardly a day passes without a deputation being appointed to proceed to the metropolis with a view of making an expedition to Sydenham. These deputations, as a rule, originate somewhat as follows:—The Electricity Committee, completely befogged by conflicting expert evidence, suggests that it should be sent to see the wheels go round. The ratepayers' friend opposes the idea *in toto*. In the end the spirit of compromise prevails; the strength of the deputation is reduced by 50 per cent., and the ratepayers' friend is induced to go with it. A flying visit to an Exhibition does not, of course, enable a layman to decide an engineering question without any further ado; but it is to be borne in mind that the opponents of the electric light at Town Council meetings usually deny its existence in any other form than that of an expensive toy; an hour or two at the Crystal Palace is a powerful antidote to such a belief.

The very sudden alternations of light and darkness which have been experienced during the last few weeks in London have kept the attendants at electric supply stations unusually on the alert. Fogs and snowstorms have quickly drifted over the streets and have been spent or dispersed several times in a day, and the facility with which electric lights can be turned on and off has been thoroughly appreciated during this unusual weather. Lamplighters have been busily employed, but it seems to have been the duty of nobody in particular to order the arc lamps to be lighted in the City.

Mr. Shelford Bidwell exhibited at the Physical Society on December 12, 1890, and again at a *conversazione* of the Royal Society, some very ingenious applications of improved selenium cells. He told the meeting how he had arranged one of these, by a relay, to switch on an electric light when daylight failed, and how he forgot all about it until it duly operated at the end of the afternoon. With his usual modesty Mr. Bidwell put forward his various adaptations of selenium cells as mere suggestions, and had he patented them and pushed them commercially we should probably have heard something more about them. It is not only feasible, but it would be very easy and not expensive, to provide a number of these cells in different parts of a town for the purpose of signalling to a supply station that the light was failing, and, where public street lighting is used, to switch the lights on and off. The street lighting in the City is worked by separate circuits, and signal wires would have to be carried back to the station. But where street lighting is worked from the ordinary supply service with sub-stations, a selenium relay might be placed at each sub-station to turn on the street lamps of that district. One modification which would be necessary would be a device to prevent continual lighting and relighting at the critical point of darkness, and another perhaps to reduce such lighting and relightings to a reasonable number in an hour.

A selenium cell connected to a bell to warn an attendant could be erected at a trifling expense at picture galleries, libraries, the Law Courts and other public institutions. At present the lights are not turned on until they are badly wanted, and are often left on long after the darkness has passed.

The electrical cooking operations, which have attracted so many visitors to the stand of the General Electric Company at the Crystal Palace Exhibition, has proved to be so popular that a room has been specially fitted up in co-operation with Messrs. Crompton & Co. for demonstrating various domestic applications of electrical energy. The internal thermal gradient and emissivity of a flat iron and the energy in calories required for a single application of curling tongs are not to be found in any text book or pocket book; and the number of pounds of coffee which can be ground, knives which can be cleaned, or boots which can be blacked per Board of Trade unit, has never yet been published. To boil a pint of water

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by electricity is easy enough. At a demonstration of the working of his electrical engine regulator about eleven years ago, Mr. Lane Fox provided electrically heated coffee for the visitors; and even at that time it was obvious that such an application of electric current offered the highest possible efficiency. There is no loss in friction, hysteresis, or polarisation; but the whole force of the great law that every form of kinetic energy always tends to degrade into heat, is used to boil the coffee.

Some figures relating to the relative expense of heating by electric current and by gas were given in *The Electrician*, January 15th, p. 271. We have examined the simple case of boiling a pint of water, and have neglected the losses, which may be very small, since the heat may be produced exactly at the point required. To boil a pint of water starting from 20°C. takes about 45,000 calories, and to do this in five minutes an expenditure of 625 watts, costing 0·42d. (at 8d. per unit), will be required. It must, however, be admitted that half a cubic foot of gas costing 0·018d. (at 3s. per 1,000) will do the same. The specific heat of a mutton chop is not given in the text books, it is probably not much above 0·5; but radiant heat is necessary, and the calculation of the energy required would be rather difficult. Mr. Tolver Preston has pointed out that the light and heat of the sun concentrated at the focus of a burning glass is nothing more than the heating of innumerable electro-magnetic fields. The mutton chop problem may perhaps therefore be handed over to Mr. Nikola Tesla.

Heilbronn.—The central station at Heilbronn, the first to be worked on the "drehstrom" system, is now running.

The Civil and Mechanical Engineers' Society.—The address of the above Society will in future be 12, Delahay-street, Westminster, S.W.

Lecture.—Mr. W. Perren-Maycock will lecture at Dulwich Scientific and Literary Association, on March 24th, at 8 p.m., on "Electricity and its Uses."

Prof. Elihu Thomson.—Prof. Elihu Thomson has presented the Académie des Sciences with the sum of money won by him in the Paris Municipality's electric meter competition.

The Bakerian Lecture.—Prof. James Thomson's Bakerian lecture on "The Grand Currents of Atmospheric Circulation" was read at the Royal Society yesterday, by the President.

Exeter.—Mr. H. G. Massingham has, by the request of the Directors and shareholders of the Exeter Electric Lighting Company, assumed, as lessee, sole control over the work of that Company.

"Leydic" Resistance.—E. Villari has been investigating the difference in the resistance offered by various metallic circuits to "the galvanic current" and to condenser discharges, and proposes to call the latter the *Leydic resistance*.

Liquid Oxygen Experiments.—At the general monthly meeting of the Royal Institution on Monday last the special thanks of the members were returned for the donations, amounting to £438, for carrying on investigations on liquid oxygen.

Electric Transmission of Power in Australia.—The Directors of the Mount Zechan Electric Power Transmission Company (Australia) intend to transmit power to the extent of 500 H.P. from the 5,000 H.P. available from the existing waterfalls of the Mount Zechan district.

Telephone Amalgamation.—The National Telephone Company have taken over the Caledonian Telephone Company under an arrangement by which the shareholders in the latter Company become shareholders in the National to the extent of their holdings in the Caledonian.

"The Electrical World."—In its issue of February 27th the *Electrical World* of New York announces the retirement of Dr. Louis Bell from the editorial chair, which he has occupied for some two years past. Mr. Carl Hering will in future be in charge of the technical department of the *Electrical World*.

Grosseto.—The town of Grosseto, Italy, has decided upon using electricity for both public and private lighting. Water power is available at a distance of two miles, and the transmission will be effected by alternating currents at 2,000 volts. Messrs. Siemens and Halske, who are providing the plant, have undertaken to have the lights running in three and a-half months.

Accumulator Litigation in Belgium.—The Société l'Electrique of Brussels, which owns the Faure patents for Belgium, having obtained the permission of the Brussels Court of First Instance, has attached all accumulators manufactured by the Société Franco-Belge pour la Fabrication de l'Accumulateur Tudor, and now threatens the Tudor company with an action for infringement and damages.

Cable Repairs :

	Date of interruption. 1891.		Date of repair. 1892.
Brest-St. Pierre Cable (Anglo-American)	Nov. 19 1892.	.. ..	Feb. 24
Zanzibar-Mombassa Cable	Jan. 25	.....	Feb. 23
Saigon-Bangkok Cable.....	Feb. 17	.....	March 1
Saigon-Singapore Cable	„ 18	.....	Feb. 25

Lighting of the Mansion House.—A private view of this installation took place on Monday evening. Some 800 lamps, ranging from 5 to 50 c.p. have been put up. The work has been carried out to the specification of Mr. W. H. Preece, and the wires have been run so that not more than ten lamps are placed upon one circuit. The work has been carried out by the Planet Electrical Engineering Company, and the current is supplied by the City of London Company.

The Phonopore.—A trial of the phonopore, says *Industries*, has recently been carried out between Lausanne and Villeneuve, on the Jura-Simplon Railway, with successful results, under the direction of the inspector of telegraphs of the Jura-Simplon Railway Company. The Railway Company is disposed to adopt the system on its lines, but owing to some disturbances on the telephone lines of Vevey and Montreux owing to induction, a difficulty has arisen with the State Telegraphs Department.

The Faure-Sellon-Volckmar Patents in France.—The *Bulletin International de l'Electricité* states that MM. Betts et Bellens, against whom the Société Française d'Accumulateurs Électriques recently commenced proceedings for infringement of the Faure-Sellon-Volckmar patents, have agreed to recognise the rights of the Société d'Accumulateurs, and to abstain from manufacturing secondary battery plates to which oxides and other lead salts are applied, except on payment of a royalty.

Copper.—During February the deliveries were 8,244 tons, against 5,587 tons during January. Once only during three years have the deliveries been so small as in January, 1892—namely, in March, 1889, when they were 4,399 tons. The supplies of the month were somewhat less than the deliveries—7,563 tons, compared with 7,005 tons in January. The stock in England and France and afloat there from Chili and Australia, was at the end of February 57,462 tons, as against 56,781 tons at the end of January.

The Proposed International Electrical Congress at Chicago.—It has been arranged by Mr. C. C. Bonney, President of "the World's Congress Auxiliary" of the Chicago Exhibition; Mr. O. Chanute, Chairman of the Engineering Congress Committee; and Mr. Elisha Gray, Chairman of the Electrical Congress Committee, that the section of the Engineering Congress relating to Electrical Engineering shall be merged into the proposed Electrical Congress. Due notice of this agreement from the office of "the World's Congress Auxiliary" will follow the recently distributed circular relating to the Engineering Congress.

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University College, Liverpool.—Prof. Oliver Lodge intends shortly to fit up and furnish an iron building as an electro-technical laboratory for students in electrical engineering at University College, Liverpool. The committee of the County Council of Liverpool have made a grant for the purpose; and the staff proposed is a highly qualified demonstrator or assistant lecturer, a mechanic, and a boy. It will no doubt develop into a larger and more pretentious building as time goes on. For their mechanical engineering the students will be under Prof. Hele Shaw in the splendidly equipped Walker laboratories. Prof. Lodge hopes to have everything ready for work on October 1st.

Electric Lighting at St. Pancras.—The Chairman of the Electricity Committee of the St. Pancras Vestry, in a letter to *The Times*, says that an impression widely prevails that the Vestry of St. Pancras, having withdrawn their Parliamentary Bill, are tired of electric lighting, and have no intention of extending it in the parish. This is entirely a mistake. The first object of promoting the Bill was to raise money from the public, when a difficulty arose between the Vestry and the London County Council as to the period over which the repayment should extend. Since then the difficulty has been surmounted, and the necessary money has been borrowed. The present necessity for the Bill, therefore, has gone.

Hertz's Experiments.—R. Ritter suggests that in order to show Hertz's experiments before a large audience, a frog, prepared as for the Volta experiment, might be placed as a shunt on the secondary conductor. When the minute secondary sparks occur they are shown to the audience by the muscular contractions of the prepared frog. L. Boltzmann says that the same result can be obtained by placing one side of the spark gap in connection with a highly sensitive electroscope, and the other with one pole of a 200-volt battery (the other pole being to earth). The leaves of the electroscope diverge whenever a spark passes. E. Wichert substitutes a feebly-charged Leyden jar for the battery employed by Boltzmann.

Prof. Hertz on Electrical Propagation.—J. A. Barth, of Leipzig, will shortly publish a work, by Prof. Hertz, entitled "Untersuchungen über die Ausbreitung der elektrischen Kraft." The articles, in which Prof. Hertz, some four years back, first gave the world the result of his brilliant investigations, were published in the "Annalen der Physik und Chemie;" and as the several volumes of the "Annalen" cannot be obtained separately, Prof. Hertz's papers are now published in a collected form. The author has added an introductory preface pointing out the connection between the different articles. Since their first publication, many scientists have been at work in the same direction, and the investigations have been amplified and completed.

The Medical Utilisation of High Potential Alternate Currents.—In a recent communication to the Académie des Sciences, MM. G. Gautier and J. Larat describe some transforming apparatus employed by them to render the alternate current supplied by the Ferranti dynamos at the Halles Centrales (Paris) available for medical purposes. They give several reasons for hoping that an extended use of the alternate current will lead to beneficial results in many forms of disease. Even in the two and a-half months during which they have had their apparatus in working order, they have obtained extremely good results in certain cutaneous affections, such as eczema. With regard to the electrical production of ozone, MM. Gautier and Larat find that the ozone always contains nitrous compounds, and may, therefore, have injurious effects.

A Smoke Recorder.—At a recent meeting of the Manchester Section of the Society of Chemical Industry, Mr. W. Thomson described an instrument designed by him for recording the density of smoke passing in chimney flues. In a number of experiments Mr. Thomson found that by exposing pieces of paper in smoky chimneys and withdrawing them after a few seconds, he obtained dark marks corresponding in depth with the amount of smoke passing up. He also ascertained that it is essential, in order that the paper should be properly marked, that it should be kept cold. His apparatus therefore consists of an arrangement whereby a strip of paper is exposed for a definite time in the interior of a chimney, being changed by clockwork after a period of exposure, while it is kept cool all the time by water circulating through the tube on which it is wound. Comparative diagrams of the actual performance of a chimney at different times are said to be obtainable in this way.

The Kerr Magneto-Optic Phenomenon.—In studying the Kerr magneto-optic phenomenon H. E. J. G. du Bois employed long ellipsoids of revolution. Du Bois concludes from his experiments that the rotation must be considered as exactly proportional to the magnetic component normal to the mirror. The rotation is negative for iron, nickel, and cobalt, positive for magnetite. Temperature does not sensibly modify the rotation constants. In the case of nickel heated to a dull red, the rotation effect disappears at the same time as the magnetic susceptibility, reappearing with it. In Du Bois' opinion the Kerr phenomenon is exclusively attributable to penetration of the ray into the interior of the metal, since its magnetisation alone has any influence, the intensity of field not directly affecting the result. Du Bois suggests that the two inverse circular components perhaps penetrate to different depths, hence the dissimilarity between the Kerr phenomenon and the rotation produced by transmitting a ray *through* the substance.

Danish Telegraphs.—According to the report on the Danish Budget for the financial year 1892-3, which has just been laid before Parliament, it appears that no profit is obtained from posts and telegraphs; but, on the contrary, a loss is estimated of £8,650 in regard to posts, and of £11,588 to telegraphs. In the course of his remarks, the writer of the report, Mr. Conway Thornton, the second secretary to the Legation at Copenhagen, says:—"It is proposed to introduce a change of tariff for telegrams, it being found that the present low rate on the one hand encourages the sending of unnecessarily long messages, and on the other destroys the profit which might otherwise be obtained on the internal service. The rates now submitted are, for inland messages, 5 ore (rather more than ½d.) per word, with a minimum of 50 ore, and for press and City messages 2 ore per word, with a minimum in each case of 40 ore and 30 ore respectively." It is calculated that a total profit on the inland service will thus be obtained of £1,600 for the first year, and £3,200 for the succeeding ones.

The Electric Light in Tunnels.—Tunnel lighting by electricity seems to be coming into vogue abroad. For some years past the famous Hoosac Tunnel has been illuminated by incandescents placed at intervals. This tunnel, it may be interesting to mention, is between Albany and Boston. It was begun in 1851, and, after being twice abandoned, was finally completed in 1875. It is five miles long, and cost the State of Massachusetts about 3½ millions sterling. The tunnel of the New York Central Railway, running into New York, is, we believe, also to be lighted electrically; and at the present moment the French technical journals are publishing some curious details with regard to the electric light installation in the Batignolles Tunnel in Paris. Here two rows of incandescents (each now containing 150 lamps) are placed in each of the three tunnels, 16ft. above the rails. By means of parabolic reflectors and diverging lenses the rays are thrown on to the walls of the tunnel. To prevent absorption by the black walls tin sheet 6½ft. broad, enclosed in a glass frame, is fixed along the brickwork. It is proposed to make use of this part of the installation for advertising and similar purposes. The installation is expected to come into operation in April.

Coast Lights.—In a letter to last week's *National Observer* Prof. Tyndall writes as follows:—

"When the *Eider* disaster occurred, and when the powerful electric light at St. Catherine's Point had been reported ineffectual, I ventured to suggest the conversion of that steadily shining light into a series of powerful flashes or thrills, which, falling on the fog after intervals of darkness, would be likely to arrest the attention of the mariner. Mr. Inglis, the Secretary of the Trinity House, promptly replied that my letter had been written under a misapprehension. The flashes, or thrills, recommended by me had, he said, been in use at St. Catherine's Point ever since 1888. This I knew to be wrong, for to my certain knowledge no flashes were exhibited at the Point in January, 1889. But, on the strength of Mr. Inglis's statement, I assumed that they must

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have been introduced subsequently, and that the error in his letter was simply a venial one of date. I am, however, concerned to find, upon inquiry, that the mistake is of a much more serious character. The changes which I assumed to have been made were never made; the electric light at St. Catherine's Point is to-day what it always has been—a quick revolving light, which never suffers extinction. No flashes such as I recommend are associated with the signal. The gravity of Mr. Inglis's misleading statement is vastly enhanced by the fact that, trusting to the accuracy of his informant, Sir Michael Hicks-Beach gave currency to the error by repeating it in the House of Commons on February 12th, thus authoritatively diffusing it throughout the civilised world. The flashes for which I contend, and have for years contended, are pulses of light, leaping instantaneously out of darkness, and falling as suddenly into darkness when their work is done."

The City Lighting.—At the meeting of the Commissioners of Sewers on Tuesday last, Mr. C. D. Harris asked permission to take at this junction the Solicitor's report on the subject of the existing electric lighting contracts. The Solicitor then submitted his report, which showed that the dates of the completion of the contracts for the Eastern and Central Districts had expired. The Clerk read a letter he had received from the City of London Electric Lighting Company, who stated that the total length of work in the Eastern and Central Districts was 31,105 yards, and of this 24,388 yards had been completed, and at the rate of progress the work would be finished in three weeks. The date of the contract for the Western District would expire on November 5th next, but the Company hoped that the work would be completed before that date. Mr. C. D. Harris asked leave to bring forward a motion to the effect that the whole question should be considered by a committee of the whole Court, with a view to inquiring into the non-completion of these contracts. Mr. Johnson strongly opposed the proposition, saying it would be a most dangerous thing to do. It was impossible for the work to be done any quicker, or the whole traffic in the City would be stopped. The Court refused permission for the moving of the resolution, by 25 votes against 15.

A Fatal Electric Shock.—On Monday last the coroner for Kent was engaged at Chatham in investigating the circumstances attending the death of Albert George Jay, aged 26, engaged as a salesman by a firm of Chatham tailors. It appeared from the evidence that shortly before six o'clock on Friday evening the workmen of the Chatham, Rochester, and District Electric Lighting Company were summoned to the shop, which is lighted by electricity, to remedy a defect. Whilst the company's foreman was in the cellar beneath the shop examining the fuses, he slipped, fell with his hand on the wire, and received a severe shock. Shortly afterwards sparks coming from the direction of the transformer, and Jay, thinking the premises were on fire, rushed into the cellar with an iron bar, to "beat the fire out." As he entered the cellar he held up the bar in a striking attitude, but immediately afterwards dropped the bar and fell back in another man's arms. He was removed from the cellar, and died in ten minutes. Dr. Walter Buchanan stated that he had made a post-mortem examination of the body, assisted by three other medical men. The appearances were entirely consistent with death from an electric shock. The following was the verdict:—"The jury are unanimously of opinion that the deceased came to his death through an electric shock by misadventure; and in their opinion greater care should be observed by the Electric Lighting Company in providing switches to turn off the current from the various circuits of wires as occasion requires, and that they should strictly prohibit workmen from executing repairs whilst the current is on."—A letter from the Secretary of the Chatham, Rochester and District Electric Lighting Company will be found in our Correspondence columns.

Electric Haulage in German Mines.—At present very little is known, says the *Colliery Guardian*, concerning the cost of electric traction in mining operations; but the following particulars regarding three German mines will, doubtless, be found of more than usual interest. The installation in the Hohenzollern mine, carried out by Siemens and Halske, comprises two main roads, each traversed by an electric locomotive. The current is conveyed to the bottom of the shaft, a depth of 650ft., by means of four insulated armoured cables. The conductors are carried overhead, and are supported from the roofs of the roads. Each locomotive is propelled by two electromotors, imparting a speed of from 40ft. to 50ft. per second to a train of about 20 tons on a line 26in. gauge. The generating plant consists of a dynamo giving 140 amperes at 300 volts. In the Zaukerada and Stassfurt mines the locomotives were built by the General Electricity Company of Berlin. In each of these cases the generating dynamos yield 75 amperes at 160 volts. In these three instances, by the employment of separate steam-engines and of a *personnel* solely attached to the working of the plants, it has been possible to arrive at the cost price tolerably accurately. The following are the figures:—

Working conditions.	New Stassfurt.	Zaukerada.	Hohenzollern.
Average distance hauled, in feet ...	2,600	2,340	2,450
Average number of wagons per day.	400	400	900
Weight of coal per wagon in cwt....	16	9¾	11

The working expenses, per waggon, comprising the wages of engine-tender on the surface, operating of the locomotives, cost of coal for the production of steam, sundries, repairs, interest and depreciation at 15 per cent., amount to 1d. at New Stassfurt, to ⅜d. at Zaukerada, and to ⅜d. at Hohenzollern. The expenses per ton mile were respectively 2½d., 1⅜d., and 1¼d. At the Richter pit the working of a roadway 3,075ft. long, by electric traction, necessitated an initial expenditure of £2,500, the steam being supplied by boilers already on the surface. The daily output is 1,200 loads of 13cwt. each. The annual working expenses at this mine amount to ⅞d. per ton mile.

The Effect of Longitudinal Magnetisation on the Interior Volume of Iron and Nickel Tubes.—In a Paper presented to the Royal Society of Edinburgh last summer Professor Cargill G. Knott establishes the broad fact, that the internal capacity of iron and nickel tubes alters appreciably when the tubes are magnetised longitudinally. The tubes experimented upon were 34·8cm. long, and were all about 3cm. external diameter. One iron tube had an internal diameter of 1cm, and another of 2cm. When experimented with, each tube was tightly corked at both ends, and through the one cork a fine capillary glass tube projected. The tube was filled with alcohol coloured with cochineal. The changes of volume were measured by the movement of the end of the liquid column in the capillary tube. This was viewed through a microscope. A movement in the tube through a distance equal to one division of the microscope micrometer meant a change of volume of $7{\cdot}2 \times 10^{-6}$ cub. cm Field strengths of 50, 125 and 250 units were employed. For the iron tubes, it was found that the transverse contraction always exceeded the longitudinal extension, so that there was on the whole a diminution of the internal space. There was evidence of the contraction attaining a maximum, which, in the case of the thinner walled tubes occurred in a field not far removed from the field which produced the maximum extension. For the nickel tube, formed by rolling up a sheet of ordinary commercial nickel to a convenient size, the transverse *expansion* differed so slightly from the longitudinal contraction, that the change of volume of the internal space, though of the same order of quantity as the corresponding change in the iron tubes, was a very small fraction indeed of the change that would result from the longitudinal contraction acting alone. In low fields, the longitudinal contraction overbalanced the transverse expansion, causing a compression. This compression reached a maximum about field 60, and then fell off first slowly, then more rapidly. About 140 it became zero, and changed sign in higher fields. In field 260 a very distinct dilatation was produced about equal to the maximum compression obtained in field 60. The rapid changes of temperature of the liquid in the heart of the magnetising coil, when the high currents were used, made accurate measurements of the changes of volume impossible; but there was no doubt as to the fact of the change of sign in the compression when the field was taken high enough. In an experiment with a glass tube substituted for the iron or nickel tube, no effect was produced; so that the alcohol itself was uninfluenced by the magnetising force. An experiment was also tried with a current of seven amperes passed along the iron tubes, so as to cause a circular magnetisation of the outer circumference. No change of volume was observed.

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THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 404.*)

§ 66. **Choice of Instruments.**—We now pass on to the consideration of the various parts of Lord Rayleigh's work, and will deal first with his method of measuring the current in C.-G.-S. absolute measure. In the use of any instrument for the determination of currents in absolute measure we have to make observations of two classes. To the first class belong all the observations which are necessary for the determination of the "constants" for the instrument; while in the second class we place the observations which have to be made during the passage of the current. The quantities belonging to the second class are variable, depending upon the strength of the current. In order that we may obtain the most accurate results, the following conditions should be fulfilled:—(1) The "constants" of the instrument should be of a very permanent character, and should not be appreciably affected by any slight relative displacements of any parts of the apparatus. (2) No quantities over whose variations we have no control should be included among the "constants" of the instrument. (3) The number of observations which have to be made with "first-class accuracy" should be as small as possible, and the quantities to be determined in absolute measure should be chosen from such as are most easily observed with accuracy. We will now discuss the principal current measurers; and examine how nearly they comply with these conditions.

§ 67. **The Tangent Galvanometer.**—The tangent galvanometer fulfils conditions (1), since a properly constructed coil is not liable to change its dimensions, and since the centering of the needle is easily effected with sufficient accuracy. It fails in (2), since a knowledge of the Earth's Horizontal Magnetic Force is required, this being a quantity which is difficult to determine, and which is subject to incessant variations. It is faulty in respect to (3), since the determination of the mean radius of a coil by the measurement of the successive layers is a difficult operation, and one which it is impossible to repeat. The absolute angle of deflection has to be observed, and this is also a difficult operation (*see* § 27.)

§ 68. **The Electro-Dynamometer.**—The electro-dynamometer is an improvement upon the tangent galvanometer as regards the earth's magnetic force, since by taking the observations properly this quantity can be eliminated; but the instrument is faulty as regards (1) because although the coils themselves are of a sufficiently permanent character, still its "constants" include the length and distance apart of the bifilar suspending wires, which will be different each time the instrument is set up afresh. It is true that these quantities have not to be observed directly, but still they affect the time of swing of the suspended coil, which has therefore to be determined on each occasion when a current has to be measured. The difficulties of the measurement of absolute angles and of the determination of the absolute mean radius of a coil again make their appearance. But besides the quantities which have to be determined in absolute measure, there are a large number of ratios which have to be measured. The theory of the electro-dynamometer was discussed in §§ 50, 51, 55, and it was pointed out that the very appearance of the final formula was a sufficient indication that the instrument, when applied to the "absolute" measurement of a current with all attainable accuracy, labours under serious disadvantages.

§ 69. **The Current Weigher.**—We will now turn to the current weigher, or electric balance, and will briefly consider how closely it conforms to the ideal conditions laid down in § 66. In this instrument a moveable coil suspended from one arm of a balance lies with its plane horizontal, and midway between a pair of fixed coils whose planes are also horizontal. The current is sent in opposite directions through the fixed coils, so that the suspended coil is attracted towards one and repelled from the other. The general arrangement may be seen from Fig. 43 (§ 48), which is now reproduced as Fig. 51. This figure, however, only shows *one* fixed coil.

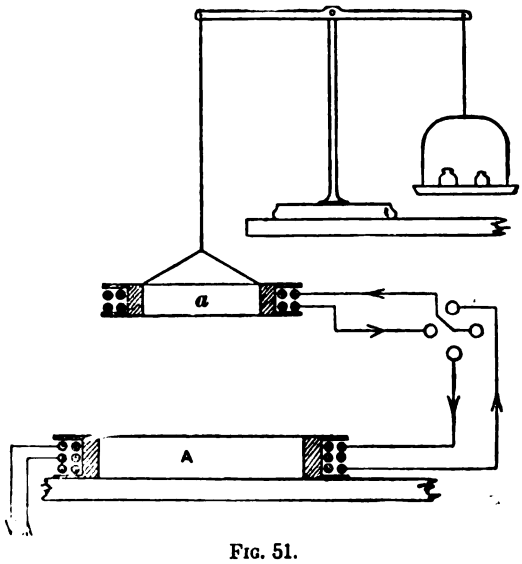

FIG. 51.

§ 70. **Lord Rayleigh's Instrument.**—Lord Rayleigh, in his work on "The Electro-Chemical Equivalent of Silver,"* employed an instrument with *two* fixed coils. Fig. 52 will serve to give an idea of the apparatus.† The two fixed coils, A_1, A_2, are those of the electro-dynamometer "constructed by the Electrical Committee of the British Association."‡ When the coils are to be used in the electro-dynamometer they are placed so as to have their planes *vertical* instead of horizontal (*see* § 51). A drawing of this electro-dynamometer will be found in Maxwell, Vol. II., p. 339. The fixed coils are wound in channels formed at the ends of a hollow brass cylinder, and thus the distance between them is absolutely fixed and their parallelism is ensured. The aperture in the front of the drum (Fig. 52), through which the suspended coil is seen, is to allow the passage of the bifilar suspension in the electro-dynamometer. The current is led to and from the suspended coil by flexible copper wires. The connecting wires are not shown in Fig. 52.

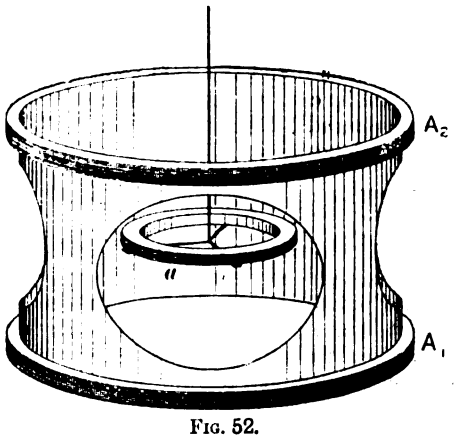

FIG. 52.

The current passes in series first through the two fixed coils and then through the suspended coil. The suspended coil, *a*, was wound on an ebonite bobbin by Lord Rayleigh; it is supported by a light brass framework which is suspended from an arm of a balance. The coil is provided with levelling screws

* *Phil. Trans. Royal Society*, 1884, Part II.

† The principal data of Lord Rayleigh's instrument were roughly as follows:

The Fixed Coils.

A = mean radius = 24·8cm.
2B = distance between mean planes = 25·0cm.
Number of turns of wire on each coil, 242.

The Suspended Coil.

a = mean radius = 10·2cms.
Number of turns of wire = 242.
Mass of wire and ebonite ring = 575 grammes.
Force experienced for 1 ampere = 4·5 grammes weight.

‡ Maxwell, Vol. II., § 725.

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resting on the brass framework, and by means of these the plane of the coil can be made horizontal. These screws are not shown in the figure.

In setting up the apparatus the suspended coil is adjusted so as to be co-axal with the fixed coils, and to have its mean plane horizontal and midway between the mean planes of the fixed coils when the balance is free and its pointer is at the zero of its scale. To measure a current a determination is made of the mass, which must be placed in the pan of the balance in order to bring the pointer to its zero position. The current is then reversed in the fixed coils, but maintained in the same direction through the suspended coil. A different mass will now be required to establish equilibrium. The weight of the difference of the masses in the two cases is equal to twice the electromagnetic force experienced by the suspended coil. The difference of mass is proportional to the *square* of the current.

§ 71. **Fulfilment of Conditions.**—The coils employed in this instrument being wound on carefully made bobbins have a very substantial and permanent character, and are very unlikely to undergo any change, so that the current-weigher conforms to the first part of condition (1). By placing the suspended coil midway between the two equal fixed coils the instrument is made to satisfy the second part of condition (2), viz., that the "constants" of the instrument should be unaffected by any slight relative displacement of any parts of the apparatus. For if F is the force between two co-axal coils of radii A, *a*, placed at a distance B + *x* apart, the current in each coil having unity for its value, we have, by Taylor's Theorem,

$$F_1 = F_0 + x\left(\frac{dF}{dx}\right)_0 + \frac{x^2}{1\cdot 2}\left(\frac{d^2F}{dx^2}\right)_0 + \ldots\ldots$$

where F_0 is the force when the distance between the planes of the coils is B, *i.e.*, when $x = 0$. The subscript $_0$ atttached to the differential coefficients indicates that they are the values of $\frac{dF}{dx}$, &c., when x is put = 0 *after* differentiation. The force between the coils when their distance apart is B − x is

$$F_2 = F_0 - x\left(\frac{dF}{dx}\right)_0 + \frac{x^2}{1\cdot 2}\left(\frac{d^2F}{dx^2}\right)_0 - \ldots\ldots$$

If then we place the suspended coil nearly midway between two equal coils fixed at a distance 2 B apart, and send the current in opposite directions round the fixed coils, so that their effects upon the moveable coil are added together, we find for the total force experienced by the suspended coil when at a distance x from the central position

$$F = F_1 + F_2 = 2\left\{F_0 + \frac{x^2}{1\cdot 2}\left(\frac{d^2F}{dx^2}\right)_0 + \ldots\right\}$$

Thu the error introduced on account of an inaccurate placing of the suspended coil depends upon the *square* of the inaccuracy, so that if the adjustment is done with a reasonable amount of care the error is quite negligible. In this way any anxiety as to the effect of slight relative displacements is entirely removed, and condition (1) is completely fulfilled.

As regards condition (2) the force experienced by the suspended coil is measured by balancing it against the attraction of the earth on the masses which are put into the pan on the other side of the balance. The estimation of the force thus depends upon the value of gravity. But "*g*" for any given locality is known with great accuracy, and any variations in its value at that locality are so small as to escape detection by the most delicate and accurate observations. Thus condition (2) is satisfied.

We have now to consider condition (3). The quantities on which the force developed by unit current depends are the mean radii A, *a*, of the fixed and moveable coils, and the distance 2B between the two fixed coils. We neglect for the present the measurements of the channels in which the wire is wound, since these only appear in some small corrections of the *second* order. We shall show that if the instrument is properly designed, a *very accurate* knowledge of B is unnecessary, and that the *ratio* of the radii A, *a* is the only quantity for which careful observation is requisite.

The electro-magnetic force experienced by the suspended coil when a current i flows through the instrument is $2i^2 dM/dx$ dynes, where M is the coefficient of mutual induction for the suspended coil and *one* of the fixed coils, and x is measured along the common axis of the coils. It was explained in § 42 that M is a "length" in the electro-magnetic scheme. Thus dM/dx being the ratio of one length to another is a pure number, and independent of the *absolute* dimensions of the system, so that its value involves only the *ratios* A/a, B/a. Let us write $A/a = \eta$, $B/a = \zeta$. Then dM/dx is some function of η and ζ, let us say $dM/dx = f(\eta,\zeta)$. Then $d\zeta = \frac{dB}{a} - \frac{Bda}{a^2}$, so that

$$df = \frac{df}{d\eta}d\eta + \frac{df}{d\zeta}d\zeta = \frac{df}{d\eta}d\eta + \frac{df}{d\zeta}\left(\frac{dB}{a} - \frac{Bda}{a^2}\right).$$

This equation shows us how the variations of f are governed by the variations of A, B, and a. Now, if keeping the radii of the coils unaltered, and always placing the moveable coil midway between the fixed coils, the latter are placed at such a distance apart that the force experienced by the suspended coil is a maximum, no *small* change in B will have any effect upon f. Hence in this case the coefficient of dB in the above equation must vanish, so that $df/d\zeta = o$. The equation then reduces to $df = \frac{df}{d\eta}d\eta$, indicating that f is simply a function of η, i.e., of the ratio A/a.

(To be continued.)

A NEW MODE OF EMPLOYING CONTINUOUS-CURRENT TRANSFORMERS.*

BY W. C. RECHNIEWSKI.

Electric lighting central stations can only economically serve a certain area of which they are the centre, and this area is the more limited the lower the pressure employed. Occasions, however, arise when it would be an excellent thing to overstep the usual limit, and supply lamps at a greater distance. There are several ways of solving the problem. Let us take for example a 110-volt station. Such a station can supply lamps to a distance of 600 to 700 metres. To go further we must have a higher voltage, either alternating or continuous at the station, and transform this higher voltage down to 110 volts at the point of consumption. If we employ alternating currents there is the inconvenience of introducing into the station a type of machine totally different to the 110-volt continuous-current dynamos. These alternators cannot act as a reserve to the continuous-current generators, and we complicate the plant and render the use of accumulators impossible. Moreover, the two low-pressure networks cannot be connected together, since one is on the alternating and the other on the continuous-current system. It would therefore be better to use continuous-current transformers. Unfortunately, these machines are expensive, and their efficiency rarely exceeds 80 to 85 per cent. There is, however, an arrangement which permits of a 50 per cent. reduction in first cost and total loss.

Let us consider a simple case, and such as often arises in practice. A 110-volt central station, as I have already pointed out, cannot economically light an area of more than 600 to 700 metres radius. Let us suppose that there are 1,000 lights 1,800 metres distant requiring current; 1,000 10-c.p. 40-watt lamps mean 40 kilowatts (110 volts × 350 amperes). We can feed this group of lamps either by a feeder in which we may make up our minds to lose 20 to 30 per cent. of the energy transmitted, and which by reason of its large cross-sectional area and great length will be very costly; or by continuous-current transformers. In the latter case the following arrangement would be the most economical. In series with the existing battery of 110-volt machines, we might place a similar 130—140 volt machine (*see* figure);† we should then have a

* From *L'Industrie Électrique*, February 10, 1892.
† From the *Bulletin Soc. Int. des Electriciens.*

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pressure of 240—250 volts at the central station. The current being transmitted along the feeder at this high pressure we could diminish the weight of copper by one-half, and yet only lose 10 to 15 per cent. in the conductor.

Deducting the volts lost in the line, we should have at the feeding point about 230 volts. Here let the current be passed through a 120/110 transformer. There would still remain available 110 volts after the current had traversed this transformer. But the secondary of the transformer also supplies current at 110 volts pressure; we can, therefore, place the two sources in parallel (*see* figure).

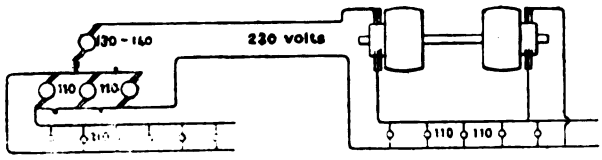


Fig. 1.

In short, the transformer has, so to speak, enabled us to lower the voltage of one portion of the current to that of the other, and to place in parallel what was formerly in series.

We therefore only transform one-half of the electric energy. The cost of the transformer is consequently one-half of what it would be had we to transform the total energy. Moreover, the loss of energy inevitable in every transformation only affects one-half of the energy supplied, so that this loss is one-half.

This system does not involve the introduction at the central station of machines of a type different to those already installed there. The device may also be made use of when a feeder becomes too small; instead of laying a new feeder we can double the voltage.

The regulation of the volts at the lamp terminals is automatic. So long as we maintain 230 volts between the two conductors we shall have 110 volts at the lamps, whatever the load, whatever the sudden variations. On no load, *i.e.*, when no lamp is alight, the two armature windings are in series, and generate a back pressure of 230 volts. When lamps are turned on, the current in the secondary reverses and begins to supply current concurrently with the direct circuit.

It is evident that instead of doubling the E.M.F. we could increase it three-fold or four-fold by the same process; but the advantage of the combination would then be less evident. The same idea can be applied to three, four, or five-wire systems. Fig. 2 shows the connections in the case of a three-wire net work. The current could be transmitted to the point of consumption at a pressure of 440 volts; it could then be passed through the primary of a transformer, which would absorb 220 volts; the secondary of which would be in two distinct portions,

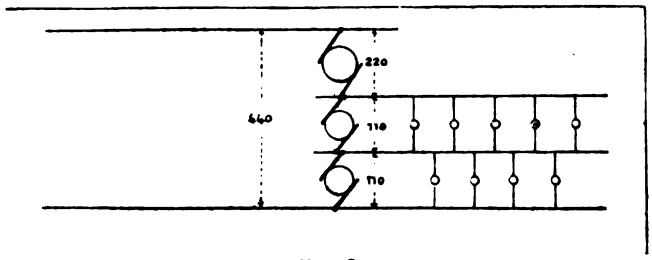


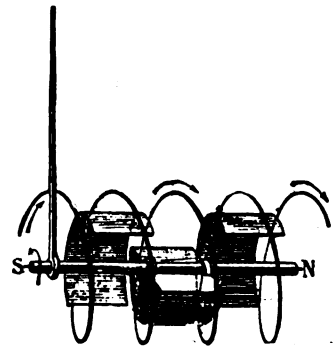
Fig. 2.

each giving current at 110 volts. The two secondaries would feed the three-wire network, as any two ordinary generators would do, with the difference that the primary current, after leaving the primary circuit, would enter the system by one external wire and leave it by the other. In this case the two secondary circuits play a double part. First of all they act as two generators actuated by the primary circuit, and furnishing current to the lamps. Secondly, they act as compensators, and equalise the potentials of the three wires in a manner analogous to the compensators used in the Clichy Sector. (See *The Electrician*, February 5th, p. 359.)

Let us now see how the question looks from the economic point of view. Take, again, our 110-volt station as an example, and consider, first of all, the results of using a feeder in which we are to lose 20 per cent. of our energy. To feed 1,000 10 c.p. 110-volt lamps 63 amperes are required. With a 20 per cent. loss in the conductor, and the lamps being 1,800 metres distant, we should require a cross-sectional area of 790 square mm. ($1\frac{1}{5}$ square inches), or 25,200 kilogrammes ($25\frac{1}{4}$ tons) of copper. If we employ the plan I have just sketched out we can use double the voltage. To render the results comparable, let us assume the same *total* loss of 20 per cent., *i.e.*, 10 per cent. in the line and 10 per cent. in the transformer. Under these conditions the line will only weigh 12,600 kilogrammes, but a 20,000 watt transformer will be required. The price of such a transformer will certainly not exceed 6,000fr., while the cost of 12,600 kilogrammes of conductor, including the cost of laying and insulating, will certainly exceed 40,000fr. The saving we thus see may be sufficiently large to justify the adoption of the method I have described.

A HARTMANN AND BRAUN AM-VOLTMETER.

The well-known German firm of Hartmann and Braun, a description of whose Frankfort Exhibition display appeared in our issue of October 30, 1891, are making ammeters and voltmeters on the Evershed principle. In the accompanying figure, which we take from *La Lumière Electrique*, it will be seen that these instruments contain a magnetising coil within which



there are thin semi-cylindrical iron shells arranged a little less than their widths apart. Similar shell-shaped pieces of iron are arranged along the axis N S of the needle, filling the intervals left between the fixed segments and slightly overlapping them. When a current is passed through the coil the movable segments are attracted upwards, the force of attraction being balanced by that of gravity. By adjusting the relative positions of the segments it is possible to obtain either wide deflections between narrow limits of pressure values, or on the other hand almost equal divisions all along the scale. The coil consists of two parts, one of copper wire and the other of nickeline, so as to compensate the variations of resistance caused by changes of temperature, and render the indications of the instruments almost independent of the temperature. The opposing force being gravity, it remains absolutely constant, and the iron being very thin its residual magnetism is very small.

THE PILSEN PHOTOGRAPHERS' LAMP.

In order to meet not only the demand for arc lamps, but the exacting and varied requirements of photographic artists, the Pilsen Electric Company have designed a lamp which is now in daily use in several large photographic studios. The apparatus consists of a specially constructed Pilsen lamp, mounted in a large dome reflector, 4ft. in diameter, and hung from a counterpoised arm, as shown in the illustration. The arm is about 8ft. long, and the lamp can be set at any desired radius

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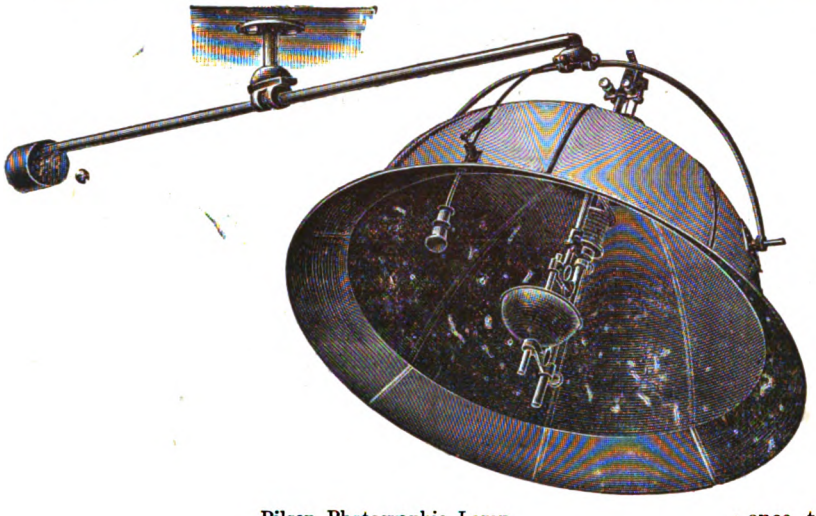
from the centre. Ball and socket joints are provided both at the centre support and at the extremity of the arm, connection with the lamp being made by flexible cables. The dome swings on trunnions, and can be set at any desired angle by a clamp, but a great variety of positions can be used by means of the two ball and socket joints alone. The lamp is usually inclined at about 45deg. The lower carbon is the positive, and is 20 millimetres in diameter; a very soft-cored carbon is used, a special core preparation being filled into hollow carbons by the Pilsen Company. The negative carbon is 15 millimetres. A current of 50 amperes is carried, and the volts vary from 47 to 56. Considerable difficulty was experienced at first with unstable arcs, which ran round the edge of the carbon roaring and flaring. This has been overcome by careful attention to the



Pilsen Photographic Lamp.

freedom of the feed and to the quality of the positive carbon. A 9in. enamelled iron bowl reflector serves to screen the direct rays of the arc from the sitter, and the main part of the light is thrown directly on the whitened interior of the dome. A very well diffused light is thus obtained.

THE ASSOCIATION OF CHAMBERS OF COMMERCE.

At the meeting of the members of this Association on Wednesday:—

Coast Communications.

Mr. Moxey (Cardiff) moved:—

"That in the opinion of this Association it is needful, for the safety of life, that the lighthouses, lightships, and coastguard stations should be in telegraphic communication with each other, and the general telegraphic system of the country where practicable."

Sir Michael Hicks-Beach, M.P., who was warmly cheered, said: I am deeply interested in the question which you have been discussing, and, so far as my personal opinion goes, I am entirely at one with you in the principles which you hold. You favoured me last year with a list of lighthouses where telegraphic communication was needful, and I was glad to find that in some of the places named there was already an existing telegraphic communication. In the others I should certainly have been prepared to act, but I could only act as the administrator of a fund which is raised from the light dues upon shipping: and therefore I thought it only right before acting to place myself in communication with the Chambers of Shipping as representing those by whom this fund is paid, and to ascertain whether in their judgment I should be justified in devoting part of it to that purpose. Not unnaturally, the Chambers of Shipping demurred to such an expenditure being placed entirely upon their shoulders. They held that it was a matter of national interest, and that, therefore, the nation ought to pay for it. I, therefore, could proceed no further in the matter, so far as the Mercantile Marine fund was concerned. If I had been able to do so I think we might have seen by this time some communications established where they do not exist to-day; but, however, I daresay nothing has been really lost, because in the meantime the attention of the public has been very much called, by yourselves and by others, to this question, and there is, no doubt, a wave of public feeling on it which I do not doubt will carry it to the conclusion which you desire. I do not at all wish now to go into the difficulties of the subject. These difficulties exist and cannot be ignored; but I understand it has been generally felt to-day that, in the first place, a commencement should be made with the principal landfalls and coastguard stations, and that an inquiry is necessary to decide how far these communications can be established with our rock lighthouses, our lightships, and places of that kind. You must remember, gentlemen, that although Chambers of Commerce may pass resolutions year after year, and although the Chambers of Shipping may entirely agree with them, as they do agree with them, in the opinion that this is a matter which should be undertaken without further delay at the cost of the nation, yet the proper tribunal by which the Government should be authorized to undertake such an expenditure is the House of Commons; and therefore I think it must be satisfactory to you to know that within a few days Sir Edward Birkbeck will bring this question under the consideration of the House of Commons; that upon that motion Her Majesty's Government will of course be prepared to state their views; and that then the House of Commons, representing the taxpayers of the country, will be able to express a definite opinion as to whether, as a matter of principle, this expenditure should be incurred, and, if it does so, of course to assure the Government of its support. I can assure you that I sympathize with you in this matter.

The Chairman (Colonel Hill, C.B., M.P.) expressed his gratification at the terms in which the discussion had been carried on. The Association could not possibly expect the President of the Board of Trade to say more than he had said upon the subject, and they would only be too glad if the Prime Minister would change the promised Committee into a Royal Commission. He congratulated the Chambers on the fact that something was to be done in the matter. He hoped no more would be heard of the bogie about the lighthouses being blown down in time of war.

Sir Edward Birkbeck, M.P., stated that every member of Parliament who had communicated with him in reference to this question was unanimously in favour of a Royal Commission to inquire into the question of outlying rock lighthouses and floating light-vessels. In regard to the general question of coast communication, they said that the matter would be dealt with by the House of Commons in a national point of view, and he had only heard of one member of the House of Commons who was antagonistic to the proposition. Every member of Parliament who had gone into the question was going to support his motion.

The motion was then carried unanimously.

Telegraph Reform.

Mr. Brittain (Sheffield) brought forward the subject of the delivery of telegrams, and moved:—

"That, in the opinion of this Association, it is incumbent upon the Post Office authorities to give the same facilities, in every respect, for the delivery of telegrams as they now afford the public for the delivery of letters; and that the Department should no longer refuse to attempt to deliver telegrams in case there might be some slight error or insufficiency in the address which would not prevent delivery in the case of a letter; and that a deputation from the Association do wait upon the Postmaster-General to confer with him upon the subject."

Upon this the Chairman said he had received the following important letter:—

"General Post Office, London, March 7th.

"Sir,—I am directed by the Postmaster-General to acquaint you that the memorial of the Association of Chambers of Commerce on the subject of the delivery of telegrams, which you submitted on the 11th ult., has received his careful consideration. In reply, I am to say that the memorialists are under a misapprehension in supposing that the officers of this department have been instructed not to attempt to deliver telegrams in cases where an obvious slip has been made in the address. On the contrary, they are enjoined to make the utmost efforts, consistently with the exigencies of telegraph business, to effect the delivery of all telegrams. The fact that an address which may suffice for a letter is not necessarily sufficient for a telegram is not due to any difference in the spirit in which the Postal and Telegraph Services are worked, but to the fact that the conditions under which letters and telegrams are dealt with are essentially different. As stated by the late Mr. Raikes, in answer to a question in the House of Commons, 'the object of the telegraph service is instant action, and it would not be possible, without serious injury to persons making use of it, to despatch messengers on voyages of discovery, which would necessarily very seriously retard the delivery of other telegrams.' In the case of letters bearing addresses which cannot be readily identified, opportunities offer for making special inquiry as to their disposal, without delaying other letters, but in the case of telegrams any inquiry must be made at once; so that the attempt to deliver one telegram, which may prove unsuccessful, will in all probability lead to the delay of several. Another point is that telegrams are not nearly so numerous as letters. The large amount of correspondence passing through the hands of postmen soon familiarises them with the names and addresses of persons residing in the district in which

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they deliver; but it is obvious that the same opportunities are not enjoyed by telegraph messengers, the delivery of a telegram being a more infrequent occurrence. With regard to the first of the two illustrations brought forward by the memorialists—namely, the supposition that if a telegram happens to be addressed to No. 3 instead of No. 2 in a given street, the regulations preclude its delivery to the person for whom it is intended, although his correct address is well known—I am to explain that, in point of fact, no pains are spared to effect delivery when a precise and apparently a complete address is given. Messengers are instructed to try such telegrams at several houses, if necessary, and frequently when the telegram is brought back to the office undelivered it is sent out a second time for further trial. In the case which the memorialists had particularly in view it appears that the addressee was a visitor at a watering place during the season, and in these circumstances the failure of the telegram in consequence of the error in its address can readily be understood. As regards the other case—that as to the sufficiency of the address 'Onslow House, Sheffield'—I am sorry to say that Sir James Fergusson considers that the postmaster of Sheffield acted rightly in informing the secretary of the Chamber of Commerce that there could be no guarantee that telegrams so addressed would be duly delivered. Bearing in mind the essential difference between postal and telegraph work, Sir James Fergusson thinks it not unreasonable to expect that in a large town like Sheffield a better address should, where possible, be given for telegrams than the name of a private house followed by the name of the town. I am told that the fact that a number of telegrams (not, indeed, forming any considerable proportion of the total) have to be treated as insufficiently addressed is due, not, as Sir James Fergusson thinks, to any want of elasticity in the Department's delivery arrangements, but to causes over which the Department has no control. Sir James Fergusson refers to the use of names instead of numbers for houses, and the want of system in naming, and even in numbering streets. These difficulties, which necessarily impede, more or less, the delivery of correspondence of all descriptions, are particularly felt in the metropolis. There are hundreds of streets in the suburbs composed of rows of houses which are not numbered, and can only be identified by such names as 'The Limes,' 'Woodville,' 'Belmont,' &c., and great difficulty also arises from the number of streets which bear the same name. A reference to the 'London Delivery Book' (a compilation used as a guide in the delivery of telegrams) shows the existence of 34 King-streets, 35 Queen-streets, 19 Duke-streets, and 24 New-streets; there are 29 Victoria-places, 33 Victoria-roads, seven Victoria-streets, and 44 Victoria-terraces; the name 'Park-cottages' appears 24 times, 'Park-place' 31 times 'Park-road' 29 times, 'Park-street' 14 times, 'Park-terrace' 41 times, and 'Park-villas' 51 times. While this state of things continues, Sir James Fergusson fears that cases of non-delivery can never be reduced below a certain *minimum*. The local authorities might, however, do much to mitigate the evil, if, indeed, it cannot be entirely removed. With that object in view the Post Office has from time to time exercised its influence with the local authorities, but the circumstances are such that the remedy rests primarily with the public. "I am, &c., "J. C. LAMB."

The motion was thereupon withdrawn.

Telephones.

A long discussion ensued upon the telephone system of the country; and on the motion of Mr. BROWN (Plymouth), seconded by Mr. WAKE (Leicester), it was agreed unanimously:—

"That in the opinion of this Association it is desirable, for the due development of the telephone system of the country, that Government be asked to take it over: provided, however, that satisfactory assurances can be obtained that the Government officials are prepared to work the system and extend it with vigour and efficiency."

Underground Telegraph Wires.

On the subject of the protection of telegraph wires it was agreed, on the motion of Mr. GROSER (Plymouth), seconded by Mr. STEIBELL (Nottingham):—

"That in the opinion of this Association it is of great importance that the telegraph wires of the country should be protected by being laid underground or in some other effective manner, so as to prevent the serious interruptions of telegraphic communication that now take place through storms and the consequent breakdown of wires and poles; and that the Executive Council be asked to take such steps as they may consider most desirable to impress on the Government the importance of this matter receiving attention."

The motion was carried, but not by a sufficient majority to allow of any action being taken.

The Chambers discussed questions of fire assurance, and adjourned until Thursday morning.

At the banquet in the evening, Sir J. GORST took occasion to mention that in the course of the present Session the House of Commons would be asked to vote a sum of money to begin the work of establishing telegraphic communication with the lighthouses around the coast. He believed that important work should be now commenced, and he did not think many years would elapse before satisfactory communication was established.

THE GENERAL ELECTRIC COMPANY.—We are pleased to learn that the damage done by the fire at this Company's Manchester works is only very slight, and that arrangements have been made by which the regular output will not be seriously interfered with.

BOOKS, &c., RECEIVED.

"Traité de Photométrie Industrielle, spécialement appliquée à l'Éclairage Électrique." By A. Palaz. (Paris: Georges Carré.)

"Calendar of the University College of South Wales and Monmouthshire." (Cardiff: Daniel Owen and Company.)

"Fortschritte der Elektrotechnik. By Dr. Karl Satrecker. (Berlin: Julius Springer.)

"Electric Railway in Theory and Practice." By Oscar T. Crosby and Louis Bell, Ph.D. (New York: W. J. Johnston Company.)

"Journal of the United States Artillery." (Virginia, U.S.A., Artillery School Press.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, March 11th.

LONDON CHAMBER OF COMMERCE.

3.30 p.m. Meeting at the Mansion House: To consider the Chicago Exhibition.

PHYSICAL SOCIETY.

5 p.m. Ordinary Meeting. Papers to be read: (1) "Thermodynamics and the Action of Light on Silver." By H. M. Elder. (2) "On Choking Coils." By Prof. J. Perry, F.R.S.

CITY AND GUILDS OLD STUDENTS' ASSOCIATION.

8 p.m. Meeting at Central Institution. Paper to be read: "The Behaviour of Insulating Materials under the Action of High Potential Differences." By H. B. and W. Fox Bourne.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Japanesque." By F. T. Piggott.

SATURDAY, March 12th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Matter at Rest and in Motion." By Lord Rayleigh, F.R.S.

MONDAY, March 14th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. III.—3. "The Uses of Petroleum in Prime Movers." By Prof. William Robinson, Assoc. M.Inst.C.E.

TUESDAY, March 15th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed: "Petroleum Engines." By Prof. W. C. Unwin, F.R.S.

WEDNESDAY, March 16th.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting. Presidential Address by Dr. C. T. Williams. Exhibition of instruments, etc.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Iceland." By Tempest Anderson, M.D.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Ordinary Meeting.

THURSDAY, March 17th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting.

CHEMICAL SOCIETY.

8 p.m Meeting. Papers to be read.

FRIDAY, March 18th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Modern Satire in Black and White." By George du Maurier.

SATURDAY, March 19th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Matter at Rest and in Motion." By Lord Rayleigh, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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The Electrician.

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A NEW AMERICAN SUPPLY STATION.

It might have been imagined that with the development of electrical engineering some convergence between English and American practice would take place; but it appears that an interchange of ideas and methods is as far off as ever. The first station in New York was that which was started by the Edison Company in 1882; and it is natural that the demand has increased to such an extent that it can no longer supply the needs of the district. Other stations have since been erected, and the oldest one, which was burned down something like a year ago, is now about to be replaced by an entirely new and fully equipped station in Elm-street. It is necessary to bear in mind, in examining an American supply station, that the designers seldom if ever work with a free hand. Unlike an English engineer, his American *confrère* cannot order his dynamos from one or several makers, his steam engines from another, and so on; he has to use the materials which go to form the "system" in vogue with his company. The details may change gradually, as one chief engineer succeeds another; but there does not seem to be much demand for careful design and planning as we understand it.

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The Edison Company has, however, made a new departure and the style of station, first inaugurated, if we remember rightly, in Philadelphia, is likely to become stereotyped as part of the "system," and future stations of this company will probably be repetitions on different scales of the new pattern. The work on the new station does not seem to have arrived at a very advanced stage, and it does not even appear from the technical papers that the type of dynamo to be used has been definitely decided upon. "The company," says the *Electrical Engineer* of New York, "favours a series-wound disc dynamo, and the indications are that such a type of machine will be used." The engines alone have been decided upon, and these are to be of the Van Vleck quadruple-expansion "disconnective" inverted type. Six or eight engines of 4,000 to 5,000 H.P. each will be put down. Our contemporary speaks of these as "an ample number of large units," but explains this statement as relating to the effect of a breakdown of one member on the working of the station. The day load of the district is said to be peculiar, attaining a maximum between 10 and 11 a.m., and admitting of nearly 12 hours run on full output. The Van Vleck engines were described in the *Electrical World* of New York of January 23, 1892. For the purpose of preventing the complete breakdown of a large engine, in case of the disablement of one part, it is arranged to run with any of the cylinders out of gear. The steam chests are placed in front of the engines instead of between them, in order to save floor-space, but the setting of cylinders in tandem is considered objectionable. The cut-off of all three cylinders in the triple-expansion engines of this class is controlled simultaneously; and while the economy of this is doubtful, especially if the increased complication of valve gear be put against it, the engine will no doubt respond more quickly to the governors. In ordinary supply work little else than a runaway governor is wanted; and if a good governor is to be used, it should be controlled electrically. The governors of the Van Vleck engine are high speed, and act on the Joy gear hydraulically. The old-fashioned governors which pull mechanically on a link, as on the engines at the generating station of the City and South London Railway, or the engine driving the Kapp dynamo at the Crystal Palace, can never compete with a relay governor which has merely to determine the application of a pull on the valve gear. Among other details which seem to many mechanical engineers a confession of weakness and not a precaution, and which owe their introduction to the electro-mechanical engineer, if we may use the not altogether flattering expression, is the provision on this engine of water-jacketed main bearings and guide surfaces. Is metal so dear, and tooling so expensive, and floor space so valuable that decent surfaces cannot be provided? Many engineers, who have been trained in the sound and steady lines of mechanical construction, never saw a babbited bearing until comparatively recently, unless in marine or railway work; and we have never yet heard any advocate for the system who did not bring in the question of cheapness. Many English dynamo makers, and we believe we are right in saying the majority of first-class engine makers, in speaking of a "brass" mean an honest gun-metal or phosphor bronze casting, and not a hollow shell run in with something like solder, which is dignified by the name of anti-friction metal.

Quadruple expansion, of course, implies high pressure, but the type of boiler for the new station has not yet been chosen. The first-class marine boiler, says the *Electrical Engineer* of New York, "of course, cannot be used on the score of safety," though the "of course" is not at all clear, seeing that multiple expansions were first introduced and have been chiefly employed in marine work. We can quite understand that our American friends have been so overrun, or shall we say infatuated, with water-tube boilers that the art of building shells and fire boxes may have become nearly forgotten in the United States; but the advisers of the Edison Company, we are now told, "are of opinion that better results can be obtained in the matter of evaporative power than can be obtained with the present type of water-tube boiler." The inhabitants of Elm-street might object to the rivetting up of shell boilers for 40,000 H.P. on the new premises; and if, on the other hand, they are supplied ready made, the makers will no doubt be requested to "deliver and fix," and will note that the boilers are to be set on a floor about 75 feet above the level of the street. But novelties do not cease here; they do not even really begin until we learn that, suggested perhaps by the marine type of engine and possibly of boiler also, a forced draught is to be provided, with a closed stokehole, and above the boilers will be "hot tanks" or rooms. "The air, on rising, accumulates all the radiant heat from the engine, piping, boilers, &c., and in the hot rooms above will attain a temperature of 100 to 150 degrees. From these hot rooms again the air will be exhausted and sent through heaters in the stack, where it will be further heated up to 300 to 350 degrees. From these heaters it will find its way to the ash-pit of the boilers, the whole forming what is now called the hot-blast system, which has been very successfully applied on many English steamers, and is now being introduced on American vessels." What the practice on board "many English steamers" has got to do with central-station work, except that space is valuable, and that in this case the load is steady, we fail to see; and, failing to see, we will keep a discreet silence. But when we come to the announcement that Mr. Van Vleck has devoted considerable study to the construction of the steam piping which will be on what is known as his "Cannon System," we find that this is little else than the ingenious method which has been designed by Mr. Ferranti, and used at Deptford, his attention having been directed to it by the fatal explosion of a steam pipe at that station.

So far for the heavy work. But ingenuity and overthrow of old-fashioned ideas are to be found in the electrical instruments which are to be used at this station. We read of a row of ampere meters with black dots for pointers, moving in vertical slots and ranging themselves "automatically to form a curve on the side wall, showing the distribution of the load on the entire system. . . . The pressure at the ends of the feeders will also be shown in a similar manner, and will form a straight line when the pressure is normal all over the system." Main ampere meters for 200,000 amperes and voltmeters by White of Glasgow, with dials two feet in diameter,—which by the bye might well be provided in all stations—sink into insignificance. How much of all this is fad? What is it going to cost? How much will it save? Are these things improvements?

These and other questions will be asked by American engineers, and the station will doubtless be watched with interest by them. But what does this mean for us? How much longer are American and English electrical engineers to walk in their different paths? They will occasionally stumble independently on the same device, as in the case of this multiple steam pipe; they will try some so-called improvement, like the water-tube boiler, or the pasted battery plate, and will use it until the original type, which was discarded while in a still immature state, has been improved in detail while retaining the principle. It would be mutually beneficial if the electrical engineers of the two nations would assist each other; but it seems that this is not to be the case at present.

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NOTES ON SUBMARINE CABLE WORK.

BY H. D. WILKINSON.

(*Continued from page 458.*)

The centipede grapnel is shown in Fig. 12. One form of this grapnel with renewable prongs is Cole's centipede. The prongs are of cast steel, two prongs being in one casting of the shape shown in Fig. 12A, and bolted to the shank of the grapnel. Trailers (as in Fig. 16) are used sometimes with the grapnels, being dragged either after or before the grapnel, to keep it

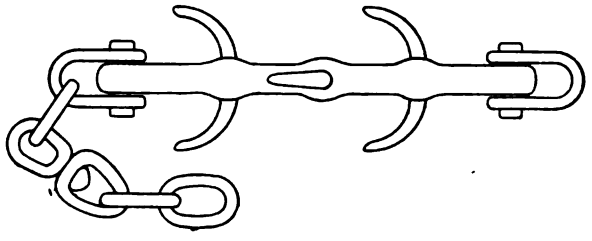

FIG. 12.—Centipede Grapnel.

from jumping, and at the same time offer a better chance of hooking the cable. There is generally also a trailing or steering chain attached to the end of the grapnel. This is a fathom or two in length, and has at one end a large link, so as to allow the other end to be rove through it after being rove through the end link of the grapnel. The noose is then hauled

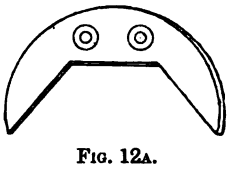

FIG. 12A.

tight, and the chain follows the grapnel, and keeps it moving in a straight line.

The forward end of the grapnel has usually about 15 fathoms of $\frac{7}{8}$in. chain attached to it to keep the front end low as it is dragged along. To the end of this chain is shackled the grapnel rope, which is usually a manilla rope, 6$\frac{1}{2}$in. cir-

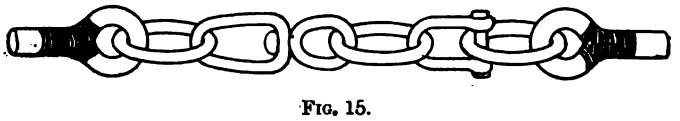

FIG. 15.

cumference, with a breaking strain of about 11 tons. A length of a few hundred fathoms of compound grapnel rope made of six cable strands of hemp yarns, with three steel wires in each, known as six-by-three rope, is generally shackled on between the chain and manilla to bear the chafing against the bottom; and this rope, for some distance near the chain, is covered with

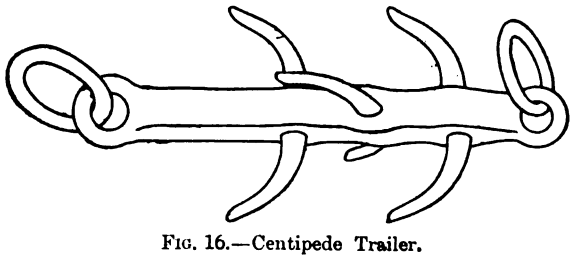

FIG. 16.—Centipede Trailer.

old matting, pieces of yarn or old rope lashed on to it in order to form a series of raised places in the rope, which will drag along the bottom, and prevent the cable from grazing along it, and so wearing away. The ends of each length of grapnel rope have thimbles and links, and one end always has a swivel and link in addition; and in coupling two lengths of rope together, one end with the swivel and link is used, and the shackle put through the two end links, as shown in Fig. 15. The swivel between each length then allows for twisting of the rope without liability to kink.

4. Special Grapnels.—When working in great depths the strain on the deep-sea type of cable is frequently the cause of its parting. To obviate this, grapnels have been devised which, simultaneously with hooking the cable, will cut it and hold the desired end. This, of course, entails grappling again, unless near a total break, but it is a more certain way to go to work, and time-saving in the long run. One of these forms of cutting and holding grapnel, designed by Mr. F. R. Lucas, of the Telegraph

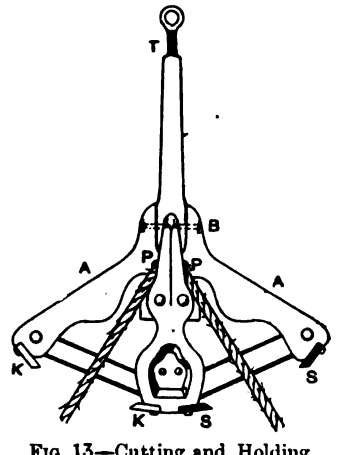

FIG. 13—Cutting and Holding Grapnel.

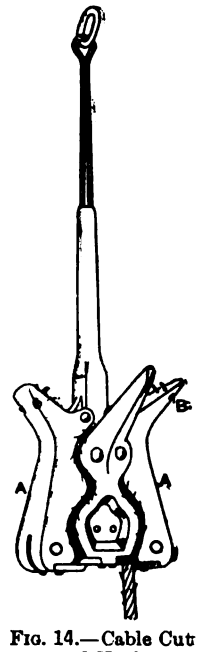

FIG. 14.—Cable Cut and Held.

Construction and Maintenance Company, is shown in Fig. 13. Two arms AA, pivoted on the pins PP, are held extended by two bolts, one of which is shown at B in the figure. These bolts are thinned down at the centre in the manner shown. The further ends of the arms carry pulleys round which a steel wire rope passes as shown, the ends of the rope passing upwards through the shank of the grapnel, where they are lashed together and form the thimble at T by which the grapnel is hauled. There are two prongs, one each side of the grapnel, and one of which is shown in the figure. On hooking the cable, the strain on the steel rope at T causes the extremities of the arms A A to bear inwards with a force which causes the bolts at B to snap off at the thin central part. The moment the bolts snap the full force of the strain is brought to bear in closing the jaws, and the bight of the cable is jammed in between the curved portions of the arms and the central stem, as shown in Fig. 14.

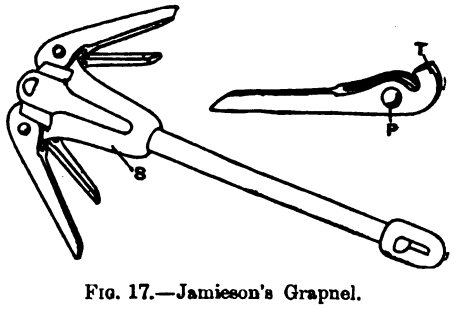

FIG. 17.—Jamieson's Grapnel.

As the jaws close, one pair of cutting edges, as at K K, close across the cable on one side, and the rapidity and force of closing cuts the cable clean through, leaving the other end firmly gripped in the jaws. The pair of knife edges shown at K K are on the near side, and would cut the left-hand side of a cable hooked on the near prong, as shown in the figure. The pair of edges S S are on the far side, and would only cut a cable caught by the far prong. In grappling it is, of course, only

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the lower prong that hooks the cable, and supposing we are looking down upon this grapnel as it is being hauled along, the underneath prong will hook the cable, and the pair of edges S S will cut the cable on the right-hand side. If, now, the grapnel should roll over a rock and turn upside down, the cable, when hooked, would still be cut on the right-hand side, as the pair of edges K K are now on that side. So long, therefore, as the grapnel is hauled in one direction with reference to the line of cable, it will always cut the cable on the side desired, no matter whether it rolls over or not, and will bring up the right end. But if the direction of grappling is reversed, the knives must be unbolted and shifted to the opposite side, in order to cut the cable on the desired side. This grapnel, which has only recently been introduced, was used on the repairs of the Lisbon-Madeira cable, which it recently cut and brought up from a depth of 1,500 fathoms. Jamieson's grapnel (Fig. 17) is designed to prevent breakage of the prongs through coming in contact with rocks. For this purpose the prongs are mounted on pins as at P, about which the prong is capable of movement. The inner end of the prong has a tongue as at T, which bears upwards against a volute spring contained in the enlarged part of the shank at S. When strained against rocks, therefore, the prongs give outwards, and as soon as the obstacle is passed the internal spring acts on the tongue and restores the prong to its position again. When the cable is hooked the prongs do not give way, because the cable lays opposite the pivot of the prong, or so close to it that no leverage is exerted. Trott and Kingsford's indicating grapnel is designed to give notice by completing the circuit of an electric bell or indicator on board immediately the cable is hooked. The weight of the cable, as it lays in the grapnel, causes a brass piston or plunger at the root of the prong to be pressed down, and an electrical contact made at the grapnel, which completes the indicator circuit through the grapnel rope. The plungers are pointed below, and when weighted by the cable force their way through a rubber disc on to a brass contact plate. The grapnel rope containing the electrical core for use with this grapnel is patented by Messrs. Trott and Hamilton, and the system is used with the Anderson and Kennelly patent indicator.

(To be continued.)

THE SMYTHE AND PAYNE FIREPROOF SYSTEM OF CONDUCTORS.

Concentric wiring systems have not unfrequently been looked upon as affording an opportunity of using insulating material which would be otherwise unsuitable either on account of mechanical or waterproof qualities. In the present example there is no mystery about the insulator; it is simply glazed earthenware, and is imperishable, and practically fireproof. The system is not at present adapted for general wiring of houses, &c., but offers considerable advantages for large halls, museums, picture galleries, libraries, banks, shops, and restaurants, while its application for churches may be seen in the ecclesiastical display of Messrs. Benham and Froud at the Crystal Palace.

The inner conductor consists of stout copper wire or rod, and the outer of split tube, made of copper strip drawn through a die. Hexagonal insulators of glazed earthenware are threaded on

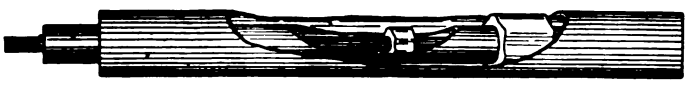

FIG. 1.

the inner conductor, and are kept in place by the spring of the split tube. [Air insulation is really employed, since the insulators are spaced about 18in. apart. An outer tube of brass or brass-cased iron, or plain iron pipe painted to suit the walls, is generally provided, and is kept from the outer conductor by larger rings of earthenware. The tube used for curtain poles is suitable for this purpose. The conductors thus arranged (Fig. 1) are made in lengths up to 18ft.; but as a rule, the whole work is measured up, and suitable lengths are prepared in the workshop ready for erection.

A number of different patterns of junction boxes and supports have been designed, and one of these is shown in the accompanying illustration. A brass box, built up of separate sides, is generally employed, plain or perforated sides being

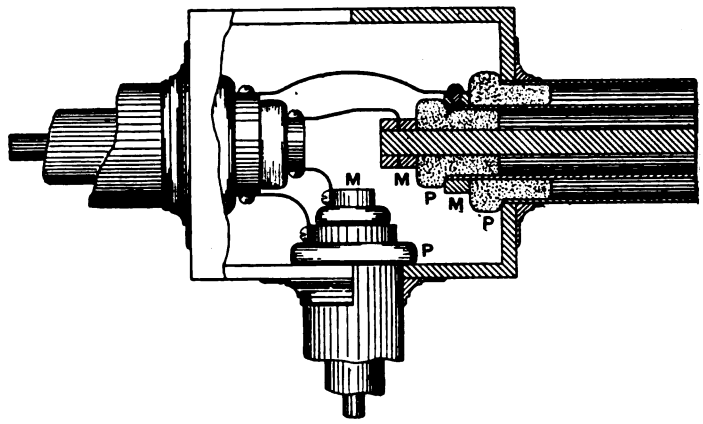

FIG. 2.—T joint of patent Fireproof Conductor. M, metal conductor; P, porcelain insulators.

provided, and fuses or switches may be mounted on them. The latest form of box has three legs to connect the top with the bottom instead of four corner pieces, allowing the conductors to be lifted out sideways without longitudinal movement. The connections shown in the illustration are made with strip or wire screwed to the conductors, but soldered sleeves are used for large tubes, and eyelets are employed for connecting thin strips, solder being applied afterwards. To avoid a general earthing of the outer conductor in event of a contact between it and the protecting tube, the latter may be divided into sections by the use of suitable earthenware insulators. The junction-boxes are readily interchangeable, and by suitable side plates may be used for simple junctions, T or double T joints, pendants, standards, or corner joints. The conductors are kept well away from wood-work, and no joiners' work or taping or ordinary insulating materials are required. The joints are always accessible, and wood casing is of course dispensed with altogether. Any leak must be a dead contact, and will therefore melt the fuse, unless an accumulation of dust and damp were to take place inside the tubes; but even in this unlikely case no fire could take place. This system offers the advantage that one class of labour is employed throughout, and the delays caused by wiremen waiting for carpenters, or the bad work which results when carpenters have to follow the wiremen, is avoided. The system readily lends itself to the construction of rows of lamps at intervals along a tube, the lampholders being fixed and connected to the conductors. Such rows would be very convenient for the lighting of shop windows, and a plain pattern with iron casing tube would be very useful for theatre work.

OIL AS AN INSULATOR.*

BY PROF. D. E. HUGHES, F.R.S., PAST PRESIDENT.

At our last meeting, Mr. Preece kindly gave me credit for being the first to propose the use of oil as an insulator for wires conveying an electric current; and in accordance with a suggestion on his part, I should like to state upon what grounds I can fairly be considered to be the first to urge upon the electrical world the use of hydro-carbon oils, such as petroleum and resin oil, for this purpose.

In 1858 universal regret was felt on the failure of the insulation of the first Atlantic cable. From the first successful laying of this cable the insulation gradually became worse, until in a few days all signals failed. The cause of this was supposed to be due to minute flaws in the gutta-percha during its manufacture, which became worse by submersion, or that lightning, or the intense currents

* Paper read before the Institution of Electrical Engineers, Thursday, March 10, 1892.

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then used for the Whitehouse induction coil, punctured the cable at several points. It appeared to me (from some old experiments of mine) that what we needed was some form of insulation that possessed self-restoring powers, so that, if punctured by lightning, or our ordinary working currents, the puncture should be closed by some simpler process than having to take up a portion of the cable. I thought that Nature showed us the way in which she restores punctures and mechanical injuries to all living objects. This is done by a flow of liquid sap in plants, or blood in animals; for if we make an incision in the bark of a tree, the sap flows out and hardens in contact with air; if we cut our fingers, blood flows out and heals the wound. Therefore I thought that if I could enclose in a cable an insulating self-restoring medium, the cable would not become dead at the first, or even after innumerable punctures To carry out this object it seemed to me that a thick insulating oil, enclosed between the wire and its outer skin, would perfectly fulfil the conditions required. Faraday had shown some years previously that oil of turpentine had a high insulating property; and this gave me great hopes that I should find, by experimenting with numerous samples of oil, the kind and quality desired for my purpose. Therefore I at once commenced a long series of experiments in order to find the best kind of oil and the most suitable form of cable to carry out this idea.

Knowing that I could not fairly test these oils, or a short length of cable, by our ordinary voltaic currents, I had recourse to the very high potential currents given by the ordinary frictional static electric machine. The method used was this: I charged a battery of Leyden jars to a known degree, which was indicated upon the Leyden jars by a Peltier electrometer; these jars, when charged, were put in communication with the short piece of the cable to be tested, the outside of which was coated with tinfoil, or placed in water connected with earth and the exterior of Leyden jars. By this means, if the insulation of the few inches of cable was bad, the Leyden jars would instantly be discharged through the defective insulation; but if the insulation was comparatively perfect, the time of discharge of the electrometer was a correct measure of its insulating properties. Of course, this method required that the Leyden jars should be perfectly insulated and hold their full charge for at least one hour when not discharging through a defective cable.

On making preliminary experiments on several samples of gutta-percha and india-rubber coated wires, I found a marked difference in each variety; but as these differences were of a constant character for each sample, it was easy to tell which of these had the highest insulating property.

These experiments showed me that if I wished to arrive at the true value of an insulating oil, I must make the experiments by a method by which the results should be entirely free from any interior or exterior coating. For this I took two small flat circular discs, 1in. in diameter, which could be immersed in oil, and by an insulated adjustable screw I could compare the striking distance of these discs in air, compared with the same when immersed in oil, and could also observe the time required for a complete discharge of the Leyden jars through this medium.

On testing numerous samples of different oils, I found not only a great difference in the species of oil, but also a great difference in different samples of the same oil; consequently a table giving the results on different oils might be misleading, as a sample of superior quality of a certain oil (although inferior in many other samples) might give higher results than a badly selected sample of a really superior oil.

The only difficulty as regards resin oil is one of manufacture, or, rather, of finding, and teaching the makers, the quality of oil best suited for the purpose; for I found, on obtaining samples of this oil from different makers, that a great difference existed as regards their insulating properties, ranging from worse than castor oil up to a degree superior to gutta-percha; and this is true of most oils; consequently, before using any oil, its quality as an insulator should be thoroughly known by constant electrical tests.

In selecting oil of high insulating quality, we must also have regard to the purpose for which it is to be used. Thus, as a self-restoring medium having very quick action, for condensers, transformers, or coils so closely wound as to be difficult for a thick oil to penetrate, a thin resin oil, such as resin spirit, might be best; but for cables and underground wires I found thick pure resin oil best, because it was not only superior as an insulator, but it would not escape too rapidly at any large puncture.

Experiments were also carried on at the same time to observe the effect of any given oil on thin sheets of gutta-percha, india-rubber, &c. These were immersed in separate vases of different oils: they were weighed before and after prolonged immersion; the result being that some oils were found to be injurious to gutta-percha, and almost all, with the exception of castor-oil, were more or less destructive to india-rubber.

I found, after numerous experiments, that pure resin oil gave the highest insulation of all, for a spark that would pierce a given thickness of gutta-percha would utterly fail to pierce the same thickness of resin oil; whilst, if the gutta-percha was pierced, its insulation was destroyed and could not be easily restored to its former condition; on the other hand, if by accident the resin oil was pierced, it, by its own mobility, at once restored the insulation to its original state. Resin oil, at the same time, had a preservative effect upon gutta-percha, for the sheets immersed in this oil had become slightly increased in weight, showing that it had penetrated into the pores of the gutta-percha; at the same time it was stiffer and tougher than before immersion. I will now show you an actual specimen of this fluid cable, cut off from a specimen one mile in length, made by the Gutta-Percha Company 33 years since. You will observe that the gutta-percha has absorbed, during that time, a large proportion of the oil, and that the gutta-percha is now, after 33 years' exposure to the air, apparently as good an insulator as whenfirst made.

Experiments were now made as to the value of resin oil when employed as the sole insulator of an electric cable. For this purpose, a short length of copper wire (say 1ft.) was coated, first, by being wound by well-dried cotton or hemp, or, better still, by a string wound round in wide open spirals, in order that the oil should penetrate as freely everywhere as possible; this was afterwards drawn into a small lead tube filled with resin oil; thus the string or fibrous covering on the wire was simply to keep the wire concentric, so as to prevent its touching any part of the exterior tube without some separation of oil or oil-saturated fibre. It will be seen that these tests were identical, both as to form and material, in their essential points, with those patented by Mr. David Brooks, of Philadelphia, some 15 years later; but as these are clearly described in my patent of January 11, 1859, there can be no question of priority in this respect, though no doubt many improvements suggested by practical experience in the mode of laying and manufacture are original with Mr. Brooks.

The insulation of this form of cable was not quite as high as solid gutta-percha, due to the fibre not being as good an insulator as the enclosed oil; but its mechanical powers of self-restoration and durability seemed to me to more than counterbalance its slightly less insulating power, for even with gutta-percha there are questions of strength and durability which ought never to be lost sight of in favour of a temporary high insulation; and I think that when the value of fluid insulation is more thoroughly known, especially for currents of high potential, it will be more generally used than at present, particularly as there are now no valid patent rights to interfere.

I again repeated these experiments, using a thinly covered gutta-percha wire for the inner conductor, drawn into a gutta-percha tube full of resin oil: this gave me very high insulation—so much so, that I tried a bare copper wire in the gutta-percha tube alone, without any resin oil: this, to my surprise, gave a far higher insulation than the best gutta-percha-covered wires as supplied to me by the Gutta Percha Company. This surprised me very much, as the tubes, which I bought at an ordinary retail shop, were known to be of an inferior quality of gutta-percha. I found afterwards that this difference was due to the tubes having been long made, and kept in stock: they had gradually dried, and were free from combined moisture absorbed during their manufacture. I proved this by taking some newly manufactured gutta-percha, and heating it gradually for a length of time sufficient to drive off its moisture: this, when modelled on a wire, so as to form a cable, gave precisely the same degree of high insulation as the old tubes that I had purchased elsewhere. I do not believe that the mechanical quality of the gutta-percha was improved by this operation; most likely it would have soon become brittle, for humidity, or an essential oil, seems necessary to its life and mechanical qualities.

I told Mr. Chatterton and Mr. Willoughby Smith, of the Gutta-Percha Company, of these results, and urged upon them the necessity of well drying the gutta-percha, and of manufacturing their cables, if possible, without constantly macerating it in water. I am not aware that my remarks had any effect, but this I remember, that in a few weeks after they gave me a sample, which they called "special gutta-percha," which certainly had as good insulating qualities as my dried gutta-percha.

As I have already said, my main object being to produce a self-restoring insulation for cables and underground wires, I found that a thin fluid, such as resin spirit or petroleum, might be objectionable, as at the point of fracture or puncture the fluid might escape with so great a rapidity as to be somewhat costly in its maintenance; but by employing a thick, heavy insulating oil, whose rate of flow would be small, this would displace any water in the puncture, provided that there was a slight head pressure given to the oil at a reservoir at certain landing stations; then it would answer all practicable purposes. For this I preferred resin oil, which is already a thick, viscid oil, and can be made more so by the addition of solid resin dissolved in it, or by the addition of palm oil residue, which has a remarkable property of thickening resin oil. In order to satisfy those who might object to even a very small leakage of oil at the puncture, I made several compounds of resin oil, mentioned in my patent, that should harden when in contact with water, and thus prevent any waste of oil at the fault or puncture.

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The static charge which I used was of high potential; the sparking distance in the air, of the charge used, was about 1in., and it showed the remarkable insulation of resin oil when 1-64th of an inch separation would effectually prevent such a spark passing through it. After having found this high insulating property of resin oil I coated all my Leyden jars, and all parts where I desired high insulation with it, and by this means I was enabled to retain a full charge of the Leyden jars for several hours in an atmosphere full of humidity.

They have lately proved the value of oil insulation in Frankfort by the use of oil in transformers of 20,000 volts, and I am convinced that in all cases where we need a high insulation, together with the power of self-restoration, it can only be found in fluid insulators. It is useful in every case where it can be applied; it is far cheaper than gutta-percha, and I have no doubt that it will soon be used for insulation in condensers as well as transformers. Mr. Nikola Tesla, in his late charming lecture, spoke highly of the use of oil in his transformers, saying that it not only gave a perfect insulation, but had the power of restoring the insulation whenever pierced or punctured, as he believed his coils were at least several times every day.

I remarked during these experiments that, no matter how high the potential, the amount of leakage was equal in time, either with a high or low charge of the Leyden jars; that is to say, when the Leyden jars were discharging at a slow rate through a good insulator, the time of falling of the electrometer through any given number of degrees was very equal throughout its whole range from 200,000 to 1,000 volts.

Being desirous of repeating this evening some of my old experiments, I applied to Mr. W. H. Preece for some of the best samples of gutta-percha-covered wires as used by the Post Office, and which he has most willingly sent me. I also applied to Mr. James Wimshurst, the inventor of the remarkable static electric machine, who at once most kindly consented to lend the machine, and also design an arrangement by means of which we could show to those at a distance the different distances of the sparking through oil compared with air.

On testing this apparatus with oil, it seemed to show that the value of oil as an insulator increased both with the potential of the charge and also with the rapidity of alternations, for when the experiments were made by an impulsive rush so as to have the greatest number of oscillations per second—say 1,000,000—then even the poorest oil, such as castor oil, showed marked superiority over air or gutta-percha. This confirms the advantage of oil, and its value in connection with the rapid alternating high-voltage currents used in our transformers of to-day. The experiments which we hope to repeat this evening have already shown us that a spark, or charge, from a Leyden jar, which would easily pierce 4in. of air, will not pierce $\frac{1}{10}$in. of resin oil; proving that oil, when resisting an impulsive rush of a charge, has 79 times higher insulation than air.

To obtain these results, we used a large and most powerful Wimshurst machine; but this evening, for convenience sake, we shall use a smaller machine. We may not be able to obtain quite as high comparative values, still we hope to obtain results showing oil to be 50 times better an insulator than air.

With the largest machine we obtained the following remarkable effects. The apparatus for holding the oil was a glass vase 4in. in diameter by 3in. deep. The lower portion of this vase had a copper plate connected with one portion of the circuit. A brass knob, $\frac{1}{2}$in. diameter, connected with the other portion of the circuit, could be raised or lowered in this vase in order to show the different striking distances when the vase contained air or oil. This gave the comparative results already mentioned; but, in addition, we noticed that when the knob was only covered three-quarters with oil, the spark rose from the upper portion to the upper portion of the vase, and then descended on the outside in order to reach the lower copper plate—a course of some 5in. through air, compared with $\frac{1}{10}$in. through oil. If now the current was increased, the current, or spark, became a continuous sheet flowing all over the entire surface of the vase, resembling in appearance a waterfall, or exactly imitating the well-known Gassiot cascade. On again increasing the charge in an attempt to pierce the oil, the spark pierced the glass vase, making a small hole of about $\frac{1}{32}$in. diameter, at a place $\frac{1}{2}$in. above the surface of the oil: thus the spark preferred to pierce the glass and travel several inches through air, rather than traverse a distance of $\frac{1}{10}$in. through oil.

I will now show several forms of oil insulation as applicable for submarine or subterraneous wires, and the remarkable power of self-restoration when the insulation is temporarily destroyed by a puncture or cut across so as to lay the wire bare for an instant.

It will be seen in the experiments following this Paper that I have arranged a battery so that one pole is connected through a sensitive galvanometer to a metal tank containing salt water, the return circuit being completed through the salt water and wire to be tested to the other pole. If we take any sample of gutta-percha-covered wire and place it in the water, the insulation seems perfect and all that could be desired; but if we make a small incision with a knife, so as to leave a minute portion of the copper exposed, then (as we already know), on placing this in the tank, the water at once percolates through the cut to the wire, and its insulation is completely and permanently destroyed. If we try this same experiment with oil cable, such as a bare copper wire in a gutta-percha tube containing oil, or, better still as a proof, a thinly coated gutta-percha wire, and this plunged into a small lead tube containing thick resin oil, the whole having the same diameter as the gutta-percha-covered wires, we find, on testing this lead-covered oil cable, that its insulation is as perfect as the gutta-percha wires. If we now cut through the lead tube and the gutta-percha wire once or several times so as to lay the wire bare, the insulation for an instant is destroyed, but in less than a second the oil percolates through the wound or cut, and its insulation is instantly restored to its previous high value.

I believe that these experiments sufficiently show the merits of a self-restoring insulating medium, such as resin oil, for all purposes where a permanent insulation of wires conveying an electric current is desirable.

In conclusion, I will mention a few proofs of my claim to be the first to recognise the value of oil insulation for wires conveying an electric current, based upon some earlier experiments, but patented January 11, 1859, entitled, "An Improved Mode of Insulating Electrical Conducting Wires," which describes and claims most of that which I have already related. I will read a few sentences, in order to prove this fact. After showing how the oil may be applied to submarine cables, and in order to claim its application to underground wires, the specification says (p. 3, line 10): "With some trifling modifications, the invention may be also applied for insulating electrical conducting wires employed on land or underground." As regards the materials used, it says (p 4, line 23): "I propose and prefer to use resin oil, rendered sufficiently thick or viscid for the purpose by the addition of resin or the solid residuum obtained from the distillation of palm oil." In order to show that the interior wire may be covered with a fibrous material instead of gutta-percha, it says (p. 4, line 34): "Instead of bringing the soft or semi-fluid restorative medium in direct contact with the enclosed wires, I sometimes first coat the wires with a non-conducting material, such as gutta-percha or india-rubber, and, if preferred, the wire may be previously covered with some fibrous material." My invention being as well adapted for numerous wires in an underground cable as in a single-wire cable, it says (page 5, line 6): "And the invention is as applicable when two or more electrical conductors are placed in one common tube or outer covering as when only one conductor is employed."

If the patent is hurriedly read it would seem as if I only intended to use the oil in connection with gutta-percha cables; but I foresaw the use of other outer covering, such as lead or iron tubes, for it says (page 4, line 37): "The insulated electrical conductor thus coated or covered is then placed in a gutta-percha or other tube." This phrase "other tube" referred to my experiments with an outer tube of lead or other metal; and I again employ the same phrase at page 5, line 13, where it says that the wires surrounded by the resin oil "may be placed in the gutta-percha or other outer covering."

A Paper on this subject was read before the Society of Arts and published in their Journal, April 15, 1859, in which I demonstrated by practical experiments the restorative powers of my fluid insulation. Sir William Fothergill Cooke, the Chairman, in reply, spoke in praise of the results, and said he "also thought the invention would be very valuable as applied to the street wires of electric telegraphs, and these afforded more facilities for testing its value." So it cannot be said that its applicability to underground wires was not foreseen at that date.

From 1858 to 1860 I tried by every means to get the various land and submarine electric telegraph companies to try this system, but in vain. I thus lost two years of valuable time, and then went to France in connection with my printing telegraph instrument, to which I devoted my whole time for many succeeding years, thus practically abandoning my self-restoring fluid insulation to the public. The cause of its failure to be used then was due to the fact that the invention was made before its time, or that the need of its use was not then as great as at the present time. I am glad to say that now, thanks to electric light and power, the use of a self-restoring oil insulation is fast coming into actual practice under the names and patents of numerous succeeding inventors; so I sincerely thank Mr. Preece for citing my early work, and thus giving me this opportunity of claiming as priority the work that I had done before and patented in 1859.

My best thanks are due to Mr. Preece for the samples of gutta-percha wires, galvanometer, &c.; to Mr. James Wimshurst for the loan of his static electric machine, and for his great assistance in preparing some of our experiments on high-tension currents; also to Grindley and Co., of Upper North-street, Poplar, for having supplied me with numerous samples of their best oil, from which I have selected the oil that I have used this evening.

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SOME EXPERIMENTAL INVESTIGATIONS OF ALTERNATE CURRENTS.*

BY ALEXANDER SIEMENS.

(*Concluded from page 464.*)

Some further experiments were made with the same alternate-current machine and transformer, and a frequency of 100 ∿ per second, to determine the striking distance in various insulating materials. The differences of potential were again measured by Sir William Thomson's static voltmeter, or, in the case of the higher ones, by his volt balance.

One series of experiments, represented by curve 18 (Diagram 7), was made by connecting the terminals of the transformer to the inner and outer conductor of concentric cables, the insulation of which consisted of impregnated fibrous material. The difference of potential was then gradually and slowly raised until the insulation gave way. Curve 18 really consists of two parts, the lower of which was obtained by breaking 35 short samples of cable, made with various thicknesses of the insulating material; the upper part, above 7,000 volts, was determined by breaking actual cables, not less than 50 yards in length, specially manufactured for these experiments.

The next series of experiments dealt with india-rubber insulation, but results proved to be extremely irregular, although a curve (Diagram VII., No. 19) has been plotted which gives the minimum voltage at which sparking occurred at the various thicknesses.

The concentric cables were tested by connecting the transformer to the two conductors; the sheets were placed between the disc and the spherical electrode. The core, when in short lengths, was covered with tinfoil; when long, it was immersed in water; and the terminals of the transformer were connected, the one to the insulated conductor, the other to the water or the tinfoil respectively.

Another set of tests was made by placing calico on the disc of the spark micrometer, and by connecting the other pole to a copper brush, such as are used in dynamo machines, resting on the calico.

Several samples of calico were tried—

(*a*) Thin calico, 0·12mm. thick, not impregnated.

(*b*) Silesia calico, 0·15mm. thick, not impregnated.

(*c*) Thick calico, 0·30mm. thick, not impregnated.

(*d*) Thick calico, 0·30mm. thick, impregnated.

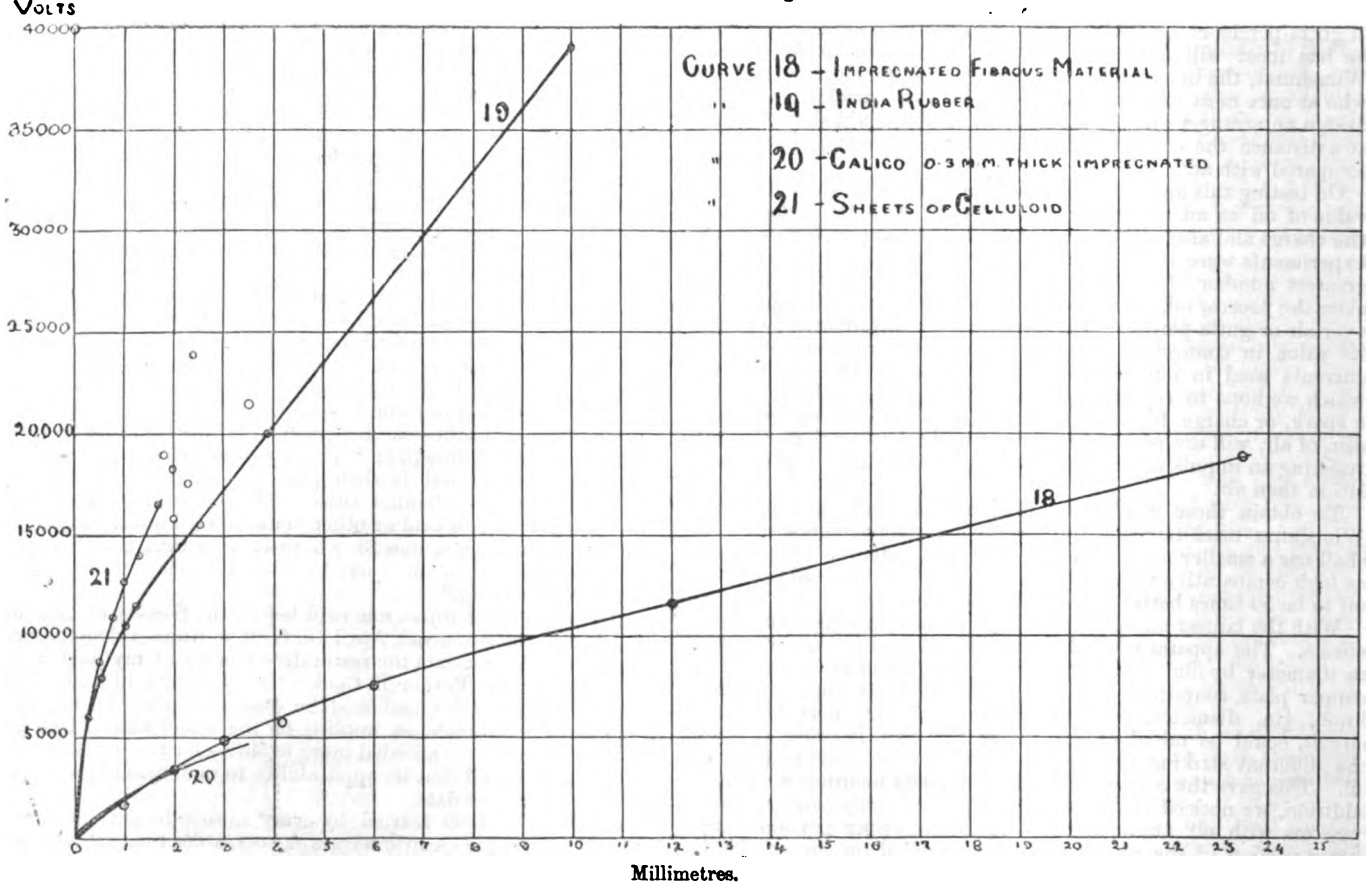
All four samples required the same lowest difference of potential —about 700 volts—for a breakdown. Different spots of the same sheet behaved very differently, some not breaking with even 1,000 volts; but at least one spot could always be found which broke down with 700 volts.

Curve 20 (Diagram VII.) gives the results obtained with several layers of the impregnated thick calico. The layers were tightly pressed together before being tested, and the points of the curve give the minimum value of the voltage which broke them down.

The last curve (Diagram VII., No. 21) records the sparking distance

DIAGRAM VII.

Sparking Distances in Insulating Materials.



through celluloid which was tested in sheets placed between the two discs of the spark micrometer.

A good many of the high-tension experiments were made with a specially constructed powerful transformer, capable of giving at its secondary terminals a current of 2 amperes under a pressure of about 50,000 volts. This is now on view at the Crystal Palace Electrical Exhibition, and various experiments are shown to exhibit its qualities. Unfortunately, it is too heavy to be shown in this Institution.

In conclusion, it should be mentioned that all the experiments described in this communication were carried out at Woolwich, at the works of Messrs. Siemens Brothers and Co., mostly under the immediate care of Dr. Baur, who was freely assisted by the heads of the various departments whenever he encounted difficulties in the course of his work.

The following table gives the details of the samples tested, and under what voltage they broke down:—

No.		Thickness of indiarubber.		
1.	40in. of 880 H wire	3·5mm.,	broke with	21,500 volts.
2.	10 yds. of experimental core ...	3·8mm.,	„	20,000 „
3.	1½ „ „ „ ...	2·5mm.,	„	16,000 „
4.	1 „ concentric cable	3·5mm.,	„	28,000 „
5.	90 „ No. 504 core.....	1·2mm.,	„	12,000 „
6.	46 „ „ 505 „	2·0mm.,	„	16,500 „
7.	50 „ „ 507 „	1·8mm.,	„	18,200 „
8.	48 „ „ 508 „	2·3mm.,	„	16,800 „
9.	5 „ „ 200 H.....	2·3mm.,	„	28,000 „
10.	1 „ concentric cable	2·0mm.,	„	17,500 „
11.	Indiarubber sheet	0·5mm.,	„	7,500 „
12.	„ „	1·0mm.,	„	10,500 „
13.	Experimental piece of core .....10·0mm.,		„	38,000 „

* Paper read Thursday, 11th February, 1892, before the Institution of Electrical Engineers.

DISCUSSION.—THURSDAY, FEBRUARY 11TH.

The PRESIDENT requested that before the discussion was commenced questions should be asked on any points of Mr. Siemens' Paper on which

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further information was desired.—Mr. SWINBURNE wished to know how long the E.M.F. was applied when determining the sparking distance, and whether when measuring in air the electrodes were steadily brought nearer till the spark passed.—A MEMBER asked what rubber was tested, whether vulcanised or not.—Mr. TROTTER asked how the thickness of the insulation in the concentric cables was measured.—Prof. FORBES suggested that any discussion on Mr. Siemens' Paper should be postponed till the next meeting, when the members would have had the opportunity of seeing it in print.

THURSDAY, FEBRUARY 25TH.

Mr. SIEMENS, in answer to the preliminary questions asked at the last meeting, said with regard to the time in the breakdown tests, half the estimated breaking pressure was first applied and then raised step by step; each rise taking some 2½ minutes, and then being left on never less than a quarter of an hour, often hours or days, before again raising. Time made no difference in air spark experiments. The vulcanised rubber tested was the same as that used for insulating cables; the thickness of concentric cable insulation was measured from the outside of the inner conductor to the inside of the outer. He considered that the way of manufacture had more to do with resisting sparking through than the actual material used.

Prof. PERRY welcomed Mr. Siemens' Paper as giving actual values in transformer work, which were much wanted. He would, however, like to have much fuller details, so as to know what weight to give to the results. He rather doubted the method of measuring temperature. 1° rise meant a variation of ·002 ohm in 1·3 ohm; and, if the battery was not reversed, thermo-electric forces might exist quite commensurate in effect with this small change of R.

Dr. FLEMING objected to Mr. Siemens' calculation of the eddy currents, which he said were all 20 per cent. too low; consequently, the hysteresis loss, which was got by deducting the eddy current loss from the total loss, was too large. Mr. Siemens' results, when corrected, made the hysteresis loss exactly proportional to the induction, the loss being $\cdot 625 \times n \times B \times 10^{-7}$ watts per cubic cm. In the eddy current loss the temperature of the core must be taken into consideration, as the loss decreased ·6 per cent. per degree rise. With fine wires the loss was practically solely due to hysteresis, but with large wires or plates the eddy currents were far more important. He considered that the alleged decrease of hysteresis loss at full load might be due to the iron getting hot and the eddy currents less than were calculated.

Mr. EVERSHED said that the last source of error pointed out by Dr. Fleming roughly counteracted the first, so that the figures given were practically right. He much preferred the use of a clinical thermometer for measuring the temperature of the core, and considered it less liable to error than resistance measurement methods. Mr. Siemens apparently made no allowance for the heating of the core by the exciting current in the copper. The way he, the speaker, employed was to pass an equivalent direct current through the windings, and note the temperature of the core. In some experiments made by himself and Mr. Vignoles, the heating observed by thermometer had been some 6 per cent. greater than that accounted for by calculated eddy currents, static hysteresis, &c. This 6 per cent. he felt inclined to attribute to viscous hysteresis.

Mr. SWINBURNE did not think that the increased heating due to increase of current in the copper caused the alleged decrease of loss in the iron. Mr. Mordey was the only one who still upheld that there was such a diminution, and in Mr. Mordey's transformer the copper was inside the iron.

Discussion adjourned.

PHYSICAL SOCIETY.

At the meeting of this Society, on February 26, 1892, Prof. W. E. AYRTON, F.R.S., Past President, in the chair, Prof. S. P. THOMPSON, F.R.S., read a Paper

"On Modes of Representing Electromotive Forces and Currents in Diagrams."

The author said he had found it advantageous in some cases to depart from the usual methods of representation, and he now brought the subject before the Society in order to have it discussed and improvements suggested. To indicate the directions of currents in wires seen end-on, Mr. Swinburne had used circles with and without crosses, but no symbol had been suggested for wires not conveying currents. He (Prof. Thompson) thought the plain circle should be used for inactive wires. A circle with a dot in the middle could then be used to indicate that a current was flowing towards the observer, and a circle with a cross in it to represent a wire conveying a current away. These meanings could be recalled by considering the direction indicated by an arrow, the dot showing the tip of the arrow and the cross the feathers. Some method of distinguishing between volts and currents was required. For this he proposed to use thin-stemmed arrows with feathers for volts, and thick-stemmed ones without tails for currents. In the case of electrical transmission of energy, this convention had the important advantage that where the two arrows had the same direction, energy was being given to the system; and where the arrows were opposite, energy was leaving it. Mr. Maycock, he said, had recently published a simple rule for finding the direction of magnetic force due to a current of known direction in a wire. Grasp the wire with the right hand, the thumb pointing in the direction of the current, the fingers will encircle the wire in the direction of the magnetic force. Dr. Fleming's well-known rule for induced currents was also a *right-hand* rule: but as

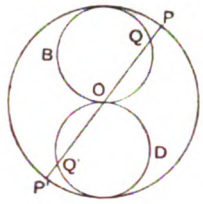


FIG. 1.

it referred to the direction of *currents*, another rule was necessary when considering motors. By making the rule refer only to volts, only one rule was required for generators and motors. For alternating currents the author found it convenient to draw polar

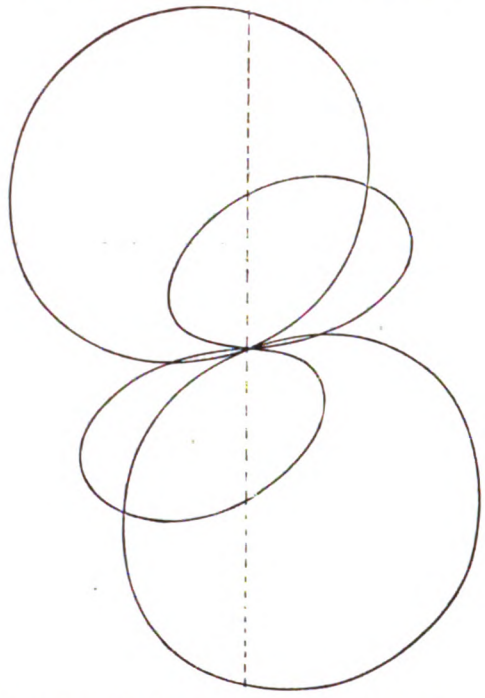
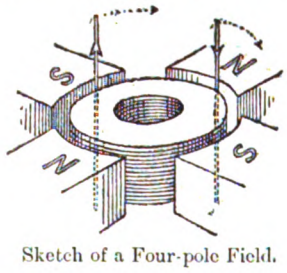
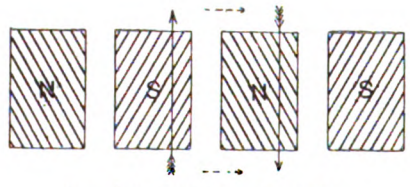


Fig. 2.—Polar curves plotted according to Prof. Thompson's method, from the curves of Profs. Ryan and Merritt. (*The Electrician*, Jan. 22, p. 296.)

curves analogous to Zeuner's valve diagrams. Suppose a line O P, (Fig. 1), representing the maximum value of an E.M.F., or current whose magnitude is a sine function of the time, to revolve at uniform velocity about O; the intercepts O Q, O Q', &c., cut off by



Sketch of a Four-pole Field.



Four-pole Field developed flat.

FIG. 3.

circles O Q B, O Q' D, will represent the magnitudes at the times corresponding to the positions O P and O P'. The effect of lag can also be represented in such diagrams. In cases where the variables are not sine functions, the curves O Q B, and O Q' D,

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are no longer circles. Polar diagrams representing the volts and current curves obtained by Prof. Ryan in his transformer experiments were exhibited, and a working diagram illustrating the changes in three-phase currents was shown. To show the directions of induced volts in diagrams of dynamos and motors, diagonal shading of the pole faces was sometimes convenient; the lines over north poles (Fig. 3) being drawn from left to right downwards *in the direction of the middle stroke of the letter* N, and those over south poles from left to right up-

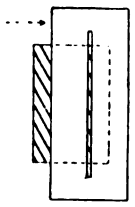

FIG. 4.—Sheet of paper, having a narrow slit cut in it, moved from left to right; the lines appear to run downwards.

wards. A conductor passing over a north pole from left to right (Fig. 4) would have an E.M.F. induced in a downward direction, as indicated by the slope of the diagonal lines. This method of representation was used to show the ways of connecting up multipolar drum armatures, the winding being supposed cut along a generating line unwrapped from the core, and laid out flat in the manner adopted by Fritsche. In connection with armatures, the author said a formula had been published, by means of which the nature of a winding, consisting of a given number of convolutions and to be used with a given number of poles, could be predetermined. This, he thought, would be very useful in practice.

Mr. BLAKESLEY said the old method of representing alternate-current magnitudes by means of the projections of revolving lines seemed preferable, for it left no ambiguity as to the directions of the quantities. The method of shading the poles also required that the direction in which the diagram was to be viewed should be known before the direction of the volt could be determined.

Mr. SWINBURNE suggested that the author might use a bow to represent volt, and an arrow for current. He was glad to see that Prof. Thompson recognised the differences in dynamos and motors, and approved of the view that mnemonic rules should refer to volt and not to current. The diagrams of drum windings would be very useful, and he hoped the author would make the subject clear to ordinary workmen in the next edition of "Dynamo-Electric Machinery."

Prof. PERRY considered it undesirable to use polar curves for anything but circles. In his opinion it was not sufficiently known that any curve can be split up into a series of sine curves and each component dealt with separately, the separate results being added together in the end.

Mr. SWINBURNE pointed out that before one could analyse a curve in this way the curve must be known, and would probably have to be determined experimentally. If means for finding one curve are available, any other required curve could probably be found by the same apparatus; hence there was no need for analysis.

Prof. PERRY remarked that experiments could not be made on a machine before the machine was built, whereas the E.M.F. curve could be predetermined from its design. By analysis its current curves when working under various conditions could be found.

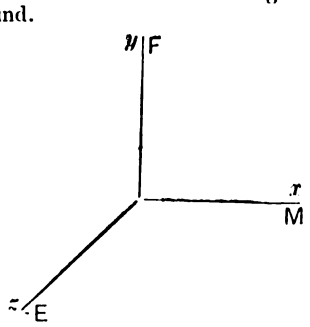

FIG. 5.

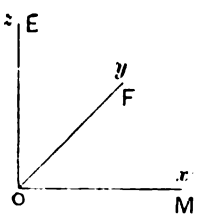

FIG. 6.

Prof. AYRTON, referring to the mnemonic character of the modes of representation described by Dr. Thompson, suggested that the symbols in the author's book should be more mnemonic. He himself was in the habit of using large letters for currents and small ones for resistance—A and a for the armature, S and s for series, and Z and z for the shunt, currents and resistances respectively, and σ and ζ for the series and shunt turns. He also found the following "electromotive force" very convenient:—Draw three rectangular axes, x, y, and z, as in Fig. 5. If then y represents the direction of the force (magnetic) O F, x that of the motion O M, then z shows the direction of the induced volts O E.

Dr. THOMPSON, in replying, said he thought Mr. Blakesley had misunderstood what had been said, for no ambiguity existed. In describing the windings of armatures, difficulty arose from want of proper names for the various elements, and in his forthcoming work suitable names had been given. To Prof. Ayrton he pointed out that in his book he (Dr. Thompson) had used mnemonic characters; for r_a, r_s, and r_m represented the resistances of armature, shunt, and series magnet coils respectively. The symbol I for current had also been recommended for adoption by the Frankfort Committee. He objected to Greek letters, except for specific quantities such as angles, specific inductive capacities, refractive indices, &c. He appreciated the simplicity of Prof. Ayrton's rule, but thought it would be better to rotate O E and O F through a right angle about O M, thus giving Fig. 6.

A Paper on "The Flexure of Long Pillars under their own Weight," by Prof. M. Fitzgerald, M.B., was read by Mr. Blakesley.

A Paper on "Choking Coils," by Prof. Perry, F.R.S., and a description of the uses of Rice's choking coils for regulating the brilliancy of incandescent lamps, by Mr. Hammer, were postponed until next meeting.

LEGAL INTELLIGENCE.

Lane Fox v. Kensington and Knightsbridge Electric Lighting Company (Limited).

MONDAY, FEBRUARY 29TH.

[Continuation of the cross-examination of Mr. Lane Fox by Sir Horace Davey.]

I think you gave a lecture, and a very important lecture, to a very important body on May 17, 1882, at the Royal United Service Institution?—Yes; I recollect it. It was a popular lecture on the future of electric lighting. It was not an exact exposition of my system, though my system was mentioned in it.

I will not read the whole of this, but there are some very interesting descriptions—at least, it interested me very much—of the difference between electricity and the electric current, and there is a very good illustration of the difference between air in motion and air at rest; and then, in the middle of the paragraph beginning "Motion of electricity or electric current can be produced in a variety of ways"—this is on page 257 of *The Electrician* of July 29—it is followed by a very clear description of the dynamo, and you can take my printed copy if you do not mind my marks. I give you the benefit of my pencil marks, which I hope you will appreciate. "It is on the external circuit," &c., &c. [*reading down to the word*] "electricity." The "earth" there, I presume, means the soil?—Yes.

Then you describe your central station, and you set up your dynamos, and then there is a paragraph beginning: "I have said the size of the mains at the central station will depend on the extent of the area over which it is proposed to distribute the current and the number of points at which it is proposed to use it in the production of light. That, however, is only true on the assumption that secondary batteries are not made use of as reservoirs of electricity, and that the current is supplied as it is wanted from the central station alone?"—Yes. I may say that accumulators meant more to me at that date than they did at the date of my patent. Their capacity as reservoirs had been very greatly increased; the manufacture of cells had become so improved that I saw the possibility of getting a very much larger reserve of power in them than I had contemplated at the time of my patent. I may say at that date the public mind was very much exercised as to the danger of the lights going out, and I laid great stress on the use of this reservoir, which I thought would relieve the public mind from its feeling of anxiety as to that danger.

In this passage which I have read does not the "earth" mean the same thing that it meant in the earlier passage, the actual earth, or, as you have asked me to call it, the soil?—It does not. I never contemplated the use of the soil at all. There are two uses to the term, one when it was in inverted commas, and there I did not speak of the actual earth or actual soil; the word "actual" preceded "earth," which makes a distinction. I spoke of "actual earth," meaning what we have agreed to call soil.

Now, this is the passage which puzzles me: "I do not mean that the pressure shall be at all points the same—that is not necessary, nor perhaps is it possible—that the pressure at any one point shall, so far as possible, be always the same." How could you get a different pressure? Did you contemplate the use of lamps of a different voltage all over the system?—I did at one time.

When you wrote this lecture?—Yes; I thought certain parts of the district might have a higher pressure than the other parts of the district, and there was a slight difference of voltage. It was a matter of the size of the conductors.

You surely must have the same pressure as long as you have enough amperes to supply your lamps at each point, but for the resistance of the mains?—But for the resistance of the mains. I was here contemplating the possibility of certain parts of the system being, generally speaking, at a higher pressure than other parts.

And that is what you meant by constancy? That is, the pressure at the same point shall always be the same?—Yes.

And that is what you get in your patent?—I meant that, yes; though in my patent I did not contemplate, I think, any difference of potential between different parts of the mains. I thought the mains would be large

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enough. I was really thinking in my patent of a small installation. I had not worked out all the various developments that a large installation would require.

"In all cases I should proposes to use the earth in some way or other, &c., &c. [*reading down to the word*] circuit." Does not the earth mean the actual earth or soil?—Yes, because the return conductor would not be insulated, and the earth would help the passage of the current. Suppose you have a metallic conductor between the two points, the fact of its not being insulated would mean that the earth would, as it were, assist the passage.

I will put it plainly. Did you not by that passage mean to suggest a return by means of the earth in the same sense and in the same manner as it was well known to electric telegraphists?—I do not mean that it was to interrupt the continuous metallic communication.

Where do you say so? In the well-known earth return in telegraphy you lead your wire down in to the soil, with an earth plate or without, and there you leave it, and do not bother yourself?—I speak of its being a good conductor.

The earth means the actual soil?—No; I make a distinction between a good conductor and the earth.

"Which is a good conductor and in contact with the earth." You tell me that means the soil?—Yes; that means uninsulated from it.

"In all cases I should propose to use the earth in some way or other as a portion of the return to the external circuit."—Quite so.

Is not the fair meaning, and the meaning which would be conveyed to any fair mind, of that passage that you proposed to use the actual soil itself—the actual earth as part of the return in a way which was well known to telegraphic engineers?—No, I was not.

Mr. JUSTICE A. L. SMITH: It does not say "at a portion," it says "as a portion."

Sir HORACE DAVEY: Yes, as a portion.

Mr. JUSTICE A. L. SMITH: You read it as if part wire and part earth, and he says any uninsulated earth to help.

Sir HORACE DAVEY: I read it as if it meant the actual soil is to be a part of the circuit.

Mr. JUSTICE A. L. SMITH: Yes, I know, and no wires through it at all.

The WITNESS: Yes; I do not mean that.

Sir HORACE DAVEY: That is what you say.—I had a certain amount of knowledge of this question, and was not likely to make a mistake of that sort.

Sir HORACE DAVEY: It was a regular insulated metallic return at Lady Conyers'?—It may have been; I am not quite certain. I should like to point out the use of metallic returns does not preclude the use of the earth so far as it assists.

Sir HORACE DAVEY: I think your lordship may take it from me in every successful installation it has been insulated returns.

Mr. JUSTICE A. L. SMITH: Do you say that?—I say the Board of Trade made a great mistake———

Mr. JUSTICE A. L. SMITH: No; do answer the question for once, and let us get on. Do you adopt that?—I dare say Sir Horace Davey is quite right.

Mr. JUSTICE A. L. SMITH: In all these installations the return has been an insulated return?—Not at all, my Lord; in a great number, especially recently, the insulation has been abandoned as quite superfluous.

Sir HORACE DAVEY: Where?—Well, there is a gentleman—I forget his name now, some electrical engineer—that advertises his system ———

I do not talk of that. I talk about something which has been done, and tell me where it is, that I may examine it.—You have had it on board ships, in a great number of ships, nearly in all cases there.

An iron ship?—Yes.

That is what you mean by an uninsulated return, a return by the iron in the vessel itself?—Yes, they are called earth.

Do you know Lord Salisbury's installation at Hatfield? Did you ever hear there they tried the plan of attaching the return wires to the iron pipe which supplies Hatfield House with water from the spring, and that they were obliged to abandon it in a very short time after several attempts on account of the corrosion of the water in the pipe?—No, I did not hear that. It depends entirely on how the connections were made.

You gave a lecture on April 14, 1881, at the Institution of Civil Engineers, but I do not find you make the slightest allusion to any of the secondary batteries by which you keep the electromotive force in the mains constant?—That lecture was got up in a great hurry. I admitted not having yet had the time to manufacture batteries myself, so that I should not give any particulars about them. I was unable to exhibit anything working, and these people I had to deal with were people who believed in nothing unless they could see it.

Do you remember very shortly after your patent was published writing a letter to *The Times*? Well, there, having pointed out the advantage, and indeed the necessity, of a constant electromotive force, you suggest some means other than the secondary batteries?—I made a slip in the use of the word "condenser."

Just one word about the infringement. You told my learned friend that you had had an opportunity of inspecting our Kensington Works. We employ dynamos for charging the secondary batteries, and other dynamos which have no connection with secondary batteries but work directly on the lights?—No, all your dynamos are connected with the secondary batteries and the system. You label some of them "charging batteries," and you label others "line dynamos," but there is no real distinction between them.

Tell me one dynamo that in 1878 was not series wound.—The one I was most familiar with was the Gramme dynamo with permanent magnets. I also made use of a separately-excited Ladd dynamo.

Our accumulators—our secondary batteries—are at the station, are they not?—Some of them are—yes.

All of them, sir?—No,

Do you know that the battery at Queen's Gate is charged by a dynamo of its own, with its own leads, and not to the main?—I should call the lead which charged it the main. It is a mere matter of detail. It is electrically connected with the mains that supply. I have not seen the connections written down. They would not let me have their connections. Absolutely refused.

Who refused?—The solicitors of the defendant company.

There are no batteries—with the exception of Queen's Gate, if that be an exception—"dotted about the system" as you suggest?—Not dotted about, but there are batteries at two important points. At Queen's Gate and at South Kensington. There is another central station at Knightsbridge.

In connection with the same system?—I believe they have means of connecting it up if they choose.

Why do you say so?—Because I say the mains are shown in the drawing I have seen in the technical papers. I have no knowledge that I can speak of with authority.

Very well, then. Then, so far as you know—I will take the South Kensington Station—there are no stations electrically connected except South Kensington and the single battery at Queen's Gate?—That is so, I believe.

Now, about the return. Is there a return by the actual soil?—No. Oh, there is where the insulator leaks.

Do you mean to say that the defendants deliberately leave a leak?—No, I do not.

You know nothing about whether the leaks of the South Kensington returns are repaired or not?—I have had conversations with their officers, and they told me that when the leaks had got beyond a certain point they used to put them right. I think they made a great mistake in having insulation for their return conductors at all.

I understand they disagree with you, and the Board of Trade disagrees with you?—No. The Board of Trade now finds that it has made a mistake.

Mr. MOULTON: The letter has been found, Sir Horace [*handing it to the learned counsel*].

Mr. JUSTICE A. L. SMITH: What is the date of it?

Sir HORACE DAVEY: It is dated February 8, 1892. It is from my clients:—"We venture to remind you that at the inspection you made recently you were shown exactly what your expert witnesses were shown on the previous occasion, and we did not understand that on the former occasion any suggestion was made that the inspection was insufficient. We are sorry that we have now found that our first idea—viz., to give you copies of the diagrams we have prepared for the purposes of our brief—cannot be carried out; but you must please take our decision on this point as final."

Re-examined by Mr. MOULTON: First of all, my Lord, I put in the letter that was written by our solicitors, to which the one that Sir Horace Davey read was an answer. It is February 6, 1892: "Dear Sirs,—We regret to hear from our clerk that you still decline to make us copies of the diagrams showing the defendants' works. You will remember that when we had the inspection at your clients' premises on Tuesday last we stated—and it was apparent to all who were present at the inspection, including your experts—that we and our scientific witnesses could obtain no knowledge of what actually went on at your clients' works without an inspection of the underground mains. It then appeared that your clients had diagrams which you said you were prepared to show us. In consequence of this we did not further inspect your clients' premises. Now, as you refuse to let us see these diagrams, we can only conclude that your clients are endeavouring to conceal something of what goes on at their premises. Under these circumstances our counsel will probably think it right, on the case being called on, to make an application to the judge to allow a minute inspection of all the underground mains, &c."

A copy of the *Engineer* of December 26, 1890, was produced; but Sir H. DAVEY objected to its use as evidence in re-examination.

Mr. MOULTON: From what you could see at these works, does the regulating action, which you have referred to, take place?—It does, yes.

The whole action of and reason for switching cells in and out was then minutely gone into.

Mr. JUSTICE A. L. SMITH: I understood that a very few days after you got your patent you took out a patent with this switching in and out in it?—Yes; there was something more there. I proposed that instead of cutting them right out they should be joined up with the others, with a similar quantity, so as to make a larger battery of them.

Mr. MOULTON: Now I want to take you to the history of this matter somewhat. At the time of your specification to which this action relates, to the best of your knowledge, had there been any description of a distribution by the parallel arc method?—None whatever.

In the defendants' system is there anything added to those elements while it is actually working?—Nothing.

After a long cross-examination on miscellaneous points, which disclosed nothing of historical interest, Mr. MOULTON said: For the purposes of regulation is "gassing" necessary?—Not the least.

But whether batteries have been bubbled or not, does that prevent their regulating action when they are once placed in the position you indicate?—No, not in the least.

TUESDAY, MARCH 1ST.

Mr. LANE FOX was briefly re-examined on a few points on Clark and Achard's patents.

Prof. SILVANUS P. THOMPSON, being then examined by Mr. MOULTON, said that he made the acquaintance of M. Planté in 1878. Up to 1878 there were no means known by which they could get light by electricity without wavering. He knew nothing in any way prior to this specification which anticipated the patent. It was an absolute revelation. The idea of mains kept at a constant potential was

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certainly new at that time. Regulating the pressure by batteries between the mains and the earth was entirely new. The lamp had not altered in character. It was still a lamp coming exactly under the description given in the first page of Mr. Lane Fox's specification.. With regard to the suggestion that the 100 volts which Mr. Lane Fox contemplates was anticipated by a statement in Staite's patent in 1847, he said that 100 cells would give anything between 190 and 36 volts.

Mr. JUSTICE A. L. SMITH: Why so?—Because, my lord, ordinary cells differ so much in their voltage. Grove cells, for example, have a voltage of 1·9 each, which equals 190 for the 100 of them, and Smee's cells have a variable voltage from about ·7 down to ·36 of a volt, or would vary from 70 to 36 volts if you take 100 of them. And both those were well known. Daniell cells were equally common.

Mr. MOULTON: Now, could this be intended to work at 100 volts?—Certainly not.

Why?—Because it works an arc lamp, and an arc lamp works at 40 to 45 volts. Staite was the inventor of the mechanism of the arc lamp.

On the question of the meaning of the term "earth," WITNESS referred to Cully's "Handbook of Practical Telegraphy," dated 1878, pages 58, 60, 61, 93, 226. "It is considered by some that the earth completes the circuit precisely in the same manner as the return wire." Then page 60, section 118: "It is better to use both the gas and water pipes for earth, so that if one be under repair the other shall still complete the circuit." "It sometimes happens that an earth cannot be found in places where there is but a thin layer of soil covering rock, or where the soil is dry." Then further down, on page 61: "All difficulty is overcome by using the iron sheath of the cable itself as an earth." The witness then briefly described the construction of a submarine cable, and referred to Mr. Sprague's "Electricity," which he said was a very well-known book, particularly for electroplaters and amateurs. At page 33, speaking of an assumption about fluid electricities, the author said: "This assumption is attended with many difficulties, all of which the molecular theory disposes of by doing away altogether with the supposed functions of the earth, which really acts simply as any other conductor does in dynamic electricity, and has nothing at all to do with static electricity. The earth connection is, in fact, nothing but a junction common to all the circuits which may be connected to it. It should be regarded as a zero or common binding screw." After other references, witness said that he had on his lecture table, in 1878, two wires, to which he could connect his apparatus for experiments. One of those wires was called "line," and the other was called "earth."

Mr. JUSTICE A. L. SMITH: Were they both insulated wires?—They were both wires stapled into the dry wood of the table, and so far insulated.

The WITNESS was then examined on the use of batteries in a supply station, and said that it was a common thing to have 55 cells, and that the battery might work with only 48. Sir H. DAVEY remarked that the defendants used 40 to produce 100 volts. The WITNESS continued, that whatever number were working at the moment the regulating action was still there, it was inherent from the very circumstance that the battery was across the mains. On Achard's patent witness said that his aim was to produce a very intense momentary current for the purpose of actuating his electric brakes. The specification would not in any way guide persons to use these batteries for any purpose of regulating. In his opinion the defendant used the system described in Lane Fox's specifications and claim. Any set of cells, whether large or small, placed across the mains from line to earth, must have a more or less equalising effect, just as truly as any fly-wheel put on an engine will tend to equalise the speed of that engine. He thought they would certainly put the middle wire to earth if they were allowed by the Board of Trade.

In reply to Sir HORACE DAVEY, Mr. Justice A. L. SMITH thought that this was not evidence.

Reference was then made to the regulations and conditions issued by the Board of Trade. "The variations of pressure from any customer's terminals shall not, during any condition of the supply which the customer is entitled to receive, nor at any time, exceed 4 per cent. from the declared constant pressure."

With regard to the light of the lamps, WITNESS next gave some figures calculated from the statistics collected by various parties from actual installations. The table of mortality, so to speak, of lives of lamps at different voltages was now perfectly well known, and on those tables of mortality he had calculated for the particular case of 100-volt lamps.

Sir HORACE DAVEY objected to this. He understood that witness was putting in a table which he had compiled from somebody else's information.

The figures which agreed with witness's experience were these. Given a lamp which was of 10 c.p. at 100 volts, and of such a goodness of manufacture that it would last 1,000 hours continuous burning, then—

Volts.	Life.	C.-p.	Volts.	Life.	C.-p.
95	3,595	7·4	101	785	10¾
96	2,751	7·8	102	601	11·3
97	2,135	8·3	103	477	12
98	1,645	8·8	104	375	12·6
99	1,277	9·3	105	284	13·3
100	1,000	10			

The efficiency in the technical sense was higher as the voltage was raised but the life was shorter.

Cross-examined by Mr. FINLAY: Would you first take Staite's patent? You told my lord on that patent 100 cells might produce anything between 190 and 30 volts. Now let me ask you, was not the ordinary cell a Daniell cell, which yielded one volt?—Oh dear, no! not at that time.

Mr. JUSTICE A. L. SMITH: What were the different classes of cells?—My brother Grove's was one.—Smee's was the best known one up to about 1836, 1837, or 1838, and then came Daniell's cells, and Grove's cells about the same time. I am quite sure he did not intend Daniell cells to be used. The object of the patent was to define the voltage, and this was his nearest approximation to a definition.

Mr. FINLAY: Now as to the arc lamps—are they not worked at 100 volts in series commonly?—No, when they are in series you allow from 40 to 45 volts for each lamp. Arc lighting can be, but is not usually, carried on at 100. I believe it is done at Kensington.

Mr. JUSTICE A. L. SMITH: We are dealing with 50 years ago, very nearly. The question is, in 1847, whether it was worked at 100 volts. That is the point.—There were no arc lamps except this, and this was the first.

Mr. FINLAY: What materials had you for saying that that arc lamp should be worked at, say, 40 volts?—Simply because arc lamps do work at 40 volts; you cannot alter the properties of the carbon.

And also at 100?—Yes, but by special devices. As a matter of fact the lamp does not get more than 45, because when you work with 100 you choke it off. Arc lamps having carbon electrodes, whether in 1847 or 1892, work at from 40 to 45 volts.

A long examination of no less than 74 questions on the meaning of the words "the earth" followed. The witness admitted that in most of the passages in Culley this expression meant the globe of the earth.

Some questions were asked with reference to the hypothetical workman in 1878. Witness pointed out that he would not be running the engine, and that there are no instructions in the specification to the engine driver or attendant at the lamps at all.

Re-examined by Mr. MOULTON: For working an arc lamp the common thing was 50 Grove cells?—That was what I used myself for years; 40 will not work a lamp quite so well. I never heard of Daniell cells being used for an arc lamp. They can, of course, be made to do so, but certainly are not suitable.

Did you ever know of Daniell cells being used for anything like currents of 30 amperes?—Yes, only for one purpose; Sir William Thomson years ago made up some special Daniell cells in trays a yard square, which would give out currents of 30 or 40 amperes. That was for a special invention of his; they were not used for any other purpose.

As a rule with 100 cells and an arc lamp there would be 40 to 45 volts pressure in the external circuit?—The arc would determine the pressure externally.

Asked as to the meaning of the word "condenser" in Mr. Lane Fox's letter to *The Times*, in September, 1878, WITNESS said that if he, in 1878, had read this passage, and he supposed he did at the time, he should have paused mentally on that word "condenser," and said, "What does the man mean? Leyden jars, or polarisation batteries—secondary batteries." He could only have meant one or other of those things. The term "condenser" was not often applied to secondary batteries—he thought he had used it himself in 1881.

Prof. WILLIAM FLETCHER BARRETT, examined by the ATTORNEY-GENERAL, said that he had devoted much attention to the history and progress of electric lighting. It was thought impossible to keep the electromotive force in the mains constant, or the pressure at the lamp itself constant. Any system of distribution, such as Mr. Fox described, with high resistance lamps, and storage cells as regulators and reservoirs of the current, was absolutely new.

The ATTORNEY-GENERAL: Was the system involving the conditions you have just described, with the then knowledge, prior to Lane Fox, regarded as a possibility?

Sir HORACE DAVEY: I object to that question.

The ATTORNEY-GENERAL: I invite my learned friend to produce anybody who will say that they thought of this as possible.

Sir HORACE DAVEY: I will invite my friend to produce anybody who has ever put it into operation.

The ATTORNEY-GENERAL: Give me simply from the specification—no more—what as an electrician you say are one, two, three, or whatever be the number of the ingredients, of Lane Fox's system?—I find in his specification the following novel points: First, high-resistance lamps made of a continuous conductor of refractory material, the quantity of light which they give being adjusted to the extent of their luminous surface—an entirely novel point. Secondly, I find a method of distribution of the current by subdivision in parallel distribution solving the problem of what was then known as the subdivision of the electric light, usually attributed to Mr. Edison. Thirdly, I find an arrangement whereby the electromotive force of the conducting mains may be kept as nearly as possible constant by a system of several generating machines, and a number of storage cells or reservoir batteries, of large conducting surface, connected up at various points of the mains. The combination of those features for the purpose was absolutely and entirely new.

The WITNESS then described the electrical plant at his laboratory. He had a gas engine, dynamo, and Planté cells joined up as described in this specification of Mr. Fox. He used any number of lamps up to ten without any regulator or switches of any kind beyond the storage cells. It had worked admirably since 1885 or 1886, and was still working. It was a regular experiment to switch off the whole of the cells and to show the unsteadiness of the lamps, and then switch them on and show their steadiness. It was quite a common thing, before 1878, when the arc ran down to switch in one or more additional cells. Sir William Siemens, in giving evidence before a Select Committee of the House of Commons on June 13, 1879, in reply to the question whether it would not be necessary to have another wire for return current said, "No, the gas and water pipes would be excellent return conductors; and if a number of central stations were to connect with these large masses of metal under the streets, the resistance of the return circuit would really become nil, and they would not only be available, but they would be extremely economical from

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an electrical point of view as return conductors." After replying to another question, the witness remarked that he thought that a great injustice had been done to Mr. Lane Fox. The system attributed to Mr. Edison of the subdivision of light was really Mr. Lane Fox's system.

Cross-examined by Sir HORACE DAVEY, Prof. BARRETT was asked how a competent electrical workman could tell what size of conducting surface to take—how many amperes to the square foot?—The very word "amperes" was not in use or known then—in 1878. He would simply know that with large generating arrangements—a large current—he must have large batteries.

If the Planté batteries are so useful and so easy to work, how do you account for the fact that Mr. Lane Fox and other gentlemen preferred to use the Sellon and Volcmar ones? How do you account for Mr. Lane Fox, who makes a display now of the advantages of the batteries, in every individual case where he put up any installation, using the Sellon and Volcmar ones?—The difficulty of forming the Planté cells at first was very considerable. It was a very tedious and tiresome process. Planté gives you full directions for it. When you have done that for days, or even weeks, together, you have a couple of cells what are called "formed." Now Faure made the remarkable discovery that you could shorten this process by putting the oxide of lead straight on the cells—instead of using plain lead to begin with, to paste on the lead to begin with. That led to an abandonment of all the troublesome processes of forming the cells. Everybody said, "We will have Faure cells;" Sir William Thomson drew attention to them over and over again as a marvellous discovery, and there was a boom (as I have heard someone say) on the subject. Then Faure cells came into the market. People tried to use them. Then they found in use that this so-called improvement, although it increased the capacity and very much shortened the time that the cells required for forming, yet was not really an improvement, because the lead tumbled off and short-circuited the batteries. Then they tried to improve it in all sorts of ways. These improvements have been tending back and back, and now they find that it is better to revert to the Planté form. That is practically what it is.

WEDNESDAY, MARCH 2ND.

Prof. BARRETT, before the cross-examination by Sir HORACE DAVEY was continued, asked to be allowed to qualify or correct an answer that he gave on the previous day. Having been asked what very large cells meant, he had replied that it obviously meant that the cells should be relatively large compared with the installation, large enough to supply a sufficient draft from the mains when the force is much used and needed. If a patentee had invented a system of heating a building by steam, and was told that he might use in large buildings heating-surfaces large enough to keep the temperature constant, an intelligent workman could carry out those directions. It would not be necessary to write a treatise on heat. It would not have been easy, if the patentee wished to use a larger conducting surface than would supply the current for him, to have indicated that by saying that it must be so many ampere hours to the square foot. In 1878, they were called "*webers*" then. The general instructions contained here would be quite sufficient for an electrical engineer to carry the installation out properly.

In the course of cross-examination, the WITNESS said that the opinion of Sir William Siemens was that the gas and water pipes, for the purpose for which he was speaking, would be good return conductors. He held the same opinion as Mr. Lane Fox did at that date.

In re-examination by Mr. MOULTON, WITNESS said that, with the exception that we now had a better mode of protection than nitrogen gas, and a better substance for the conductor than platinum-iridium, no change had, in his opinion, been made in the lamp since Lane Fox's patent.

Prof. GEORGE FORBES, examined by Mr. MOULTON, said that he had given instructions for the construction of the central station of the St. James and Pall Mall Electric Company, and had to do with the specifications for the central stations of the Metropolitan Company. He also had to select the dynamos for the House-to-House Electric Supply Company, West Brompton. Apart from the action of the Board of Trade, he did not think people would trouble to insulate their returns now. In the case of the St. James's and Pall Mall Company, which used the three-wire system, he distinctly prepared the plans for the middle wire being the cast-iron pipe containing the other two, and specified that that should be connected and quite uninsulated, in order that any assistance that the earth could give would be given, but they were stopped by the Board of Trade regulations. Mr. Ferranti also, in the mains coming from the great central station at Deptford, was anxious to leave the return conductor uninsulated, but was prevented by the Post Office. In the case of electric tramways there were many thousands of electric tramcars at work in the United States, and nearly all of them had uninsulated returns.

Cross-examined by Mr. FINLAY, WITNESS said he thought it would be a very good plan, if using switches, to have a man at each battery. A boy was not very expensive, and it was not a thing which required any great attention. He did not know that the batteries at Kensington were not connected to the mains while charging. That was new to him completely. He did not exactly know how the defendants used their batteries. He thought they were being charged at the moment that they were supplying the current to the lamps. He had very little knowledge about it. He considered secondary batteries most essential for the steadiness of the light in 1885. He did not think he could name a low-tension continuous-current central station in the country without secondary batteries. He had noticed that the lamps in the court were very unsteady; they varied 15 or 20 volts. Many persons, not electricians, if it were done gradually, would hardly know the falling of 15 volts—would not know that it was much below. They could read by it very well. He had found on circuits in London variations of more than 8 per cent. There was a 40 per cent. variation in the Athenæum Club.

After cross-examination on statements which he had made at various lectures, the WITNESS said that the "bubbling" of a cell indicated over-charging. Every practical electrician knew what was meant by thoroughly charging up; it meant when the specific gravity of the electrolyte was brought up to the proper density, he adopted 1,200. The only way to keep a battery in good order was to have a hydrometer continually at work.

After a few questions about "earth," Prof. FORBES, re-examined by Mr. MOULTON, said that a passage in one of his lectures which had been referred to related to the high-pressure system of charging batteries in series, and discharging them after shutting them off from the charging mains. The use of feeders would not prevent the Lane Fox system from having its regulating effect.

[This concluded the case for the plaintiff.]

Sir HORACE DAVEY, in opening the case for the defendants, confessed that they took a radically different view of the meaning of the patent from that put forward by the other side. In the first place, he contended that there was no patentable invention; that the so-called invention merely consisted of putting side by side two known things, each of them operating and intending to operate in the old manner; that there was no thought or application, and no direction—no invention shown in the manner of the combination. Secondly, that the combination had been anticipated both by Clark and by Achard; that it was a combination for supplying electricity by the joint action of a generator, a source of electricity, and a secondary battery for the purpose of sending a current through for using at a particular point, and that it does not make the slightest difference for what purpose the current of electricity is used. It merely consisted of passing electricity to the required point for use at that required point. Thirdly, the so-called invention as described in the amended specification was useless for any practical purpose. It was useless for the purpose for which it was described. In the first place, the earth—the actual earth—was absolutely impracticable for the purpose for which it was described in the specification. Without a system of extra cells and switches it was impossible to work what was described in Lane Fox's specification for the purpose of storing electricity to be used when wanted. The patentee, according to their view, described a system by which electricity was to be stored up in a reservoir. It may be that it had the incidental advantage of regulating the electromotive force of the currents. It was an incidental advantage. It was not invented by the patentee. It was inherent in the thing itself. A man could not take out a patent for discovering a new property of an old thing. If you used Planté batteries as reservoirs for storing up your electricity, you would also gain the advantage of regulating your current. Whatever was the merit of Mr. Lane Fox's suggestions, they remained in the region of suggestions, and had never gone beyond it—crude suggestions stated with many details which were absolutely unworkable, and, even when the matter was narrowed down to the form in which they saw it now, they remained still crude suggestions without any sufficient description or directions enabling those suggestions to be carried out in the form of a workable machine.

The two principal grounds upon which they attacked the insufficiency of the specification were, first, that the patentee directed them to use very large conducting surfaces in the cells. It was incumbent upon the patentee to tell them how large. The witnesses said, "Oh, but you are not to charge fully, and you are not to discharge fully." There was nothing of the kind in the specification. His learned friend the Attorney-General invented a phrase which did him the utmost credit. The phrase which he used was "the *plateau*." There was nothing about the plateau in the specification, and no direction in the specification which led in the direction of the plateau. His friend might be quite right for aught he knew to the contrary. Then, again, about the other cells. His client's system was a totally different one. For the purpose of storage it was absolutely essential that you should use extra cells which were capable of being put in and out and worked by a complicated arrangement of switches. No gentleman had come to say that he had ever heard of any application of this combination without the system of switches, with the exception of the laboratory installation of Prof. Barrett, and those two or three hours that the lamps were run at Lady Conyers', which of course he would have to deal with. But in every case, whether they had been put in at the instance of Mr. Lane Fox—as at the Brush Company's—or under his directions, as the lamps in the Opera House in Vienna, or at the King of Roumania's Palace at Sinaia, near Bucharest, or at the Drapers' Company under the direction of Prof. Silvanus Thompson, or whether it was at any of the installations which were mentioned by Prof. Forbes, at every one of them they would find that in fact these switches were found necessary. That was a very striking fact. According to their view, their combination or system was strikingly different; it was a different combination, it was a different system altogether. They had, going from the central station, various branches called "feeders," which lit a small portion of the district. The feeder was brought back to the main so as to form a complete circuit. They did not think secondary batteries useful for the purpose of regulation at all—they did not want them for that purpose; what they wanted them for was for supplementing the work of their dynamos for economy, for enabling them to work with smaller plant than they would otherwise be able to do.

[Sir Horace Davey then went on to the bench and explained a model at length to his lordship.]

His witnesses would offer any explanations which might be necessary upon the complicated and beautiful system by which from time to time the quantity of current and the potential were adapted to the needs of the installation. It was found by practical men that if you let the batteries discharge there was a gradual, sensible, susceptible, mischievous drop in the current. Mr. Lane Fox would not agree that it was so large as their witnesses had observed it to be; but he agreed that there would be a drop in the current which would operate to lower the potential on the whole system. It was to meet that drop that they from time to time brought into operation additional batteries which were ready charged. There were a great many people at Lady Conyers' ball. They could not

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all be dead. Not one of them had come, except Mr. Lane Fox, to tell them anything about that installation. It was one of the misfortunes of Mr. Lane Fox that there was always something that prevented the success of his schemes. At the Law Courts, where Mr. Crompton superintended, Mr. Crompton did not know the "A B C," it was notorious that Mr. Crompton was too stupid! It might be so; but Mr. Crompton had put up a larger number of installations, certainly in England, than any living man. Then workmen were so stupid, they did not understand! He quite agreed. What did it all point to? That the directions were insufficient. They could not all be Lane Foxes. It was idle for Mr. Lane Fox to come before the Court and say that the reason why this had not been carried out was because there was a conspiracy against him among the Directors of the Brush Company. The patent had been amended in such a way as to make it appear that there was a patent for automatic regulation, when the patent which was originally granted was granted for something wholly different. He could not strike out the whole of his detailed description of his regulator, and then say, "I have still got a patent for regulating electric light, because what I have described there for another purpose will operate as a regulator." All he told them about regulation was that the regulation was to be effected by the regulator.

THURSDAY, MARCH 3RD.

Sir HORACE DAVEY, continuing his opening speech, called attention to the disclaimers, and submitted that the word "regulating" ought to have been struck out, because regulating in the original patent did not refer to any automatic action of the secondary batteries, but it did refer to a mode of regulation which the patentee said was necessary for the working of the system, and which he called "my regulator," and which he claimed as the mode of regulation which he had patented. You might, no doubt, strike out of the specification—the law was very indulgent—a thing a man had put in by inadvertence, or things he had put in thinking they were novel. But you could not alter what was left by making it a new invention or a different invention (Ralston v. Smith, 11th House of Lords, p. 223), so as to make the patent when disclaimed claim a different invention from that which was claimed by the original specification. In the original specification he meant regulation by the regulator, which he said was necessary for the success of his system, with an added recommendation that it was advisable or desirable to use a large number of secondary generators and generating machines. He struck out that which he described as the regulator or as the necessary regulator, and then said, "I still have a patent for regulating the electric light." How could he? It altered completely the scope of the patent.

The principle upon which the lamps should be constructed was indeed stated. It was, in fact, intended to be an incandescent lamp; but if the lamp was part of the mode claimed he did not claim the lamp as such; but if, as Prof. Barrett seemed to think and Mr. Lane Fox himself obviously thought, he was the author and was entitled to the honour of the discovery of the lamp which alone had made incandescent lighting a successful mode of lighting, then that lamp was a useless lamp. Mr. Lane Fox stated in this, as he did in a great many of his patents, general principles, but he failed to work them into successful details. The peculiarity of Edison's patent was a filament of carbon, and enclosed in as perfect a vacuum as could be got.

He now came to the description of distribution. "The way in which I distribute the electric energy is as follows:—From one pole or electrode of the electric generator or generators situated at A, Fig. 3 (see *The Electrician*, February 26th, p. 438), proceed one or more large conductors, from which branch out, at various points where lights are desired, smaller conductors, which again may have conductors branching off from them, and so on; the other pole or electrode of each electric generator is connected with the earth, so that the conductor and its branches and sub-branches will be perpetually in a state of electric tension, tending to develop currents in every direction to the earth." Now, a faint attempt had been made to suggest that that mode of distribution as such was new. There was a claim for it. It had been disclaimed as of doubtful utility, and as of doubtful validity.

Mr. JUSTICE A. L. SMITH: It still stands in the patent, does it not?

Sir HORACE DAVEY: Not for the mode *per se*, only for the combination. It all came back to this, that it was the parallel system of arrangement as distinguished from the series system of arrangement in lamps, and the very name "multiple arc" showed that it had been introduced and was known in the days of arc lighting. There was no novelty in it.

Some of Mr. Lane Fox's experts thought that "the earth" meant every kind of return conductor; others, including Mr. Lane Fox himself, though he was a little uncertain about it, that it meant not every kind of return conductor, but an uninsulated conductor, "any return conductor where isolation is not required." Now, where a patentee described a particular mode, then that particular mode was an essential element of his combination, and that Mr. Lane Fox expected to derive particular advantages from using the earth as a return conductor. Even if the use of the words "the earth" was intended to cover all conductors of every kind whether insulated or uninsulated, still it at any rate included the earth; and, further, he would endeavour to establish by evidence that it had been tried and it had been found practically useless for the purpose of electric lighting. If a return by means of the earth itself was part of the plaintiff's combination, his answer was, they did not use it, and, therefore, did not infringe that particular combination, and the patent being a combination of several things, each of which was not claimed either as a novelty or as being useful, and had in fact been disclaimed, then the patentee was confined strictly to the combination which he had described.

Mr. JUSTICE A. L. SMITH: He does not claim anything for this in the patent.

Sir HORACE DAVEY: He claims the combination.

Mr. JUSTICE A. L. SMITH: Do you say it is necessary to infringe all parts of a combination?

Sir HORACE DAVEY: You must infringe the essential parts of it, my lord, and if this is part of the description from which he sought to get an advantage, then it is an essential part of the combination.

In his original patent Mr. Lane Fox claimed the mode of distribution *per se* as a separate invention; he claimed the mode of measuring *per se* as a separate invention; he claimed the mode of regulating; he claimed the mode of obtaining light. Well, of course, they could not do any one of those things without infringing his patent; but he had struck all that out and disclaimed it all. His patent was now confined to a combination of A and B. It was therefore a pure combination patent.

The ATTORNEY-GENERAL: A combination claim, I agree, not a combination patent.

Sir HORACE DAVEY: I do not know what my learned friend's distinction is. If they used "A" and "B" in exactly the same way as they had heretofore been used, but without any invention or ingenuity in the mode in which "A" was applied to "B" and the combination was formed, then there was no invention in the patent. [Lister *v.* Leather (Elli - Blackburn); Harrison *v.* The Anderston Foundry Company; Clark *v.* Adie (two appeal cases, p. 315); Murray *v.* Clayton (Goodeve, p. 314, 7th Chancery Division, p. 570)].

Mr. JUSTICE A. L. SMITH: Supposing it was feasible in 1878 to come back by earth (I do not say it was) and then the Board of Trade intervenes afterwards, would that smash up the patent?

Sir HORACE DAVEY; No, my lord.

Mr. JUSTICE A. L. SMITH: Then you must say it was unfeasible in 1878.

Sir HORACE DAVEY: Yes, my lord; the directions of the Board of Trade cannot make any alterations in the rights of a patentee. It can do a great many things, but cannot alter the laws of nature.

Mr. Lane Fox tells us we are to use our battery as a reservoir, so that by increasing the electromotive force during the hours when not much electricity is being used, they will become charged. What was the meaning of "charged"? That was English language. They did not want the gentleman to tell them that. That was a question of the meaning of the English language. Would his learned friend say that when a toast-master at a City banquet asked the company to charge their glasses in order to drink the Attorney-General's health, that that meant to fill them three-quarters full? To charge a vessel meant to fill it. He had no doubt that the direction was that the batteries were to be charged—not necessarily overflowing—nobody was so absurd as that—but that they were to be charged. In addition to the absence of any directions for not charging the battery beyond what was called the plateau, the absence of that was very much confirmed by what he now took to be an established fact by Prof. Forbes, although it was denied by Mr. Lane Fox, and that was, that the batteries rapidly deteriorated if they were not charged to their full extent. The expression used was it was necessary for the "health" of the cells. Mr. Lane Fox having made some suggestions, he now asked that those suggestions may be read and put in force, and he came forward now in the fourteenth year of his patent to ask that these suggestions should be read by the light of accumulated experience, which had been gained since the incandescent light had been introduced, and to be put in force by the law. The directions in the patent were wholly insufficient. There were no directions, and they had no right to impose upon the electrician or the workman who had to take the patent in hand the labour of experiment and trial—of failure, it may be—experiment, trial, failure, or ingenuity; and it was not enough to produce it to Sir Frederick Bramwell, or Dr. Hopkinson, or Prof. Silvanus Thompson, and say, "Can you carry this out?" The process was to be worked by a man with 30s. a week. What was the workman to do? How was the workman, from the vague general direction that the cells were to have a very large conducting surface, to know all that was required? How was the workman, from a direction that he was to use the batteries as reservoirs, and that he was to charge them during the hours when there was not much light burning, to know that he was only to charge them up to a certain undefined limit?

Mr. JUSTICE A. L. SMITH: They say on the other side that the engine-driver must knock off when he gets his light too bright.

Sir HORACE DAVEY: Then you will not store the batteries.

Mr. JUSTICE A. L. SMITH: They say you have got it up to the plateau.

Sir HORACE DAVEY: Yes, but you will not store your batteries. The answer to that is twofold. In the first place, you will not store your batteries, and, in the next place, you are told here that the electromotive force is to be increased, so that the engine-driver is told to increase his electromotive force during those hours. He is expressly told so.

Coming to the last part of the patent, namely, what his friends called "regulation." He had already pointed out that the patentee had left out one part of the sentence. It was the first time in his limited experience that he had ever known an amended specification which stopped at a semi-colon. If they looked at page 5 they would see: "In order to keep the electromotive force in the electric mains constant, it is desirable to have in the first place several generating machines, also a number of reservoir batteries as before explained" [semi-colon] "next it is necessary to have some regulator such as that about to be described." He stopped in the middle of the sentence, he struck out "next it is necessary." It was the first time in his legal experience that he had ever known of a case in which one retained "in the first place," and struck out what was to happen in the next place. He ventured to say that this alteration completely altered the meaning and scope of the patent, that it gave an entirely new meaning to the words in the title of the patent and in the claim at the end. He might observe again what one always noticed in Mr. Lane Fox's patents—the vague, general, large language—how it was desirable to have "several" generating machines. How many? "Several generating machines." How could anybody be said to infringe that? Did they infringe it if they had had two? And if so, why? According to Mr. Lane Fox's view, the object

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of sprinkling or dotting secondary batteries about the system was to secure local constancy. If that were a material part of Mr. Lane Fox's system all he could say was that they did absolutely nothing of the kind for the purpose of equalising and getting rid of the resistance in the mains, which would no doubt affect the actual amount of potential at any particular part of the system. They had a totally different device. They had a system of what was called feeders. The feeders went direct from the station. There was a feeder for different parts of the district which they lit. They went direct from the station, and they returned to the mains, the consequence of which was that they did not affect that particular district by the loss in the mains which would result if the main were taken to the district itself, and there was all the loss by resistance, when loss had taken place in the main before it was rejoined by the feeder which had taken the current to the district; and, therefore, if that was Mr. Fox's system of regulation, then all he could say was they did nothing whatever which in the remotest degree resembled it. The wires which connected the battery at Queen's Gate with the dynamo which actuated it at Kensington contained no lamps. They were called "charging mains," but Mr. Lane Fox spoke contemptuously of the name. He said, "You call them charging mains." In no sense whatever was this battery in Queen's Gate placed between the mains and the earth, as described by Mr. Lane Fox. Even if he conceded that Mr. Lane Fox had discovered what the world did not know at that time, that a secondary battery when used for the purpose of storage would also have the effect of regulating and steadying the current, that would not be subject matter for a patent.

Mr. JUSTICE A. L. SMITH: Not if he stated it in his patent?

Sir HORACE DAVEY: I think not, my lord, because he would be merely stating a property which was inherent, as the witness said.

Mr. JUSTICE A. L. SMITH: Supposing he found out that it was inherent?

Sir HORACE DAVEY: I think not. A man has been accustomed to eat his soup with a spoon, and somebody suggests that to use a spoon would be a good way of eating peas, which puzzle some people. You could not have a patent for that. It is an inherent part of the advantages of a spoon. That is, of course, a most vulgar illustration; but it is an illustration which is frequently given. You cannot take out a patent for teaching a person the best way of using a machine which he has got.

Mr. JUSTICE A. L. SMITH: Which nobody knew how to use before?

Sir HORACE DAVEY: Yes, suppose nobody knew how to put that machine to beneficial use. If he introduces an amendment into that machine—an alteration in that machine—which will enable it to do work which it could not do before, that is the proper subject of a patent; and if a man merely discovers a more beneficial way of using a new machine without making amendments in the machine or altering the machine, or altering the general purpose for which it is to be used, he cannot get a patent for that, because that is nothing more than teaching the world the most beneficial use to which to put the machine. Planté has told you his cell will store electricity for as long as you like or as short a time as you like, and it will give it out when wanted; but somebody says, "I will tell you what it is. If you use that in connection with an electric current, you will find it very useful for taking up flickering." That would be merely telling me of a useful application which I can make of my own machines. You cannot get a patent by pointing out to me the inherent properties which I do not know of the patent—which I am perfectly ignorant of, and which you perhaps have discovered—the inherent properties of that machine. You cannot get a patent so as to prevent me using that machine in the way which is most beneficial and profitable to me.

FRIDAY, MARCH 4TH.

Continuing his speech, Sir HORACE DAVEY cited several cases to show that combination of well-known things, without invention, was not a proper subject for a patent. "Horton v. Mahon" was an action for infringement in the construction of gasholders. The old way of making a hydraulic joint was to rivet two angle irons together. The patent was for the use of double angle iron or channel iron for this purpose. It was perfectly apparent and palpable that double angle iron would answer the same purpose, and save two rows of rivets, and consequently much additional labour. The whole claim of the patentee, therefore, amounts to this—he informs the manufacturers of gasholders that by the use of an article well known in the iron trade much labour and expense may be spared. That clearly is not the subject of a patent. And he said that if they use a reservoir in the mode in which a reservoir was used, without any change in the construction of a reservoir, merely taking a well-known machine, Planté's cell, and he tells them they can use it beneficially with a current for incandescent light—that that is not the proper subject matter of a patent. He returned to the failure of the early installations, and said that Mr. Lane Fox showed absolute indifference as to the fate of the specimen installation at the offices of the Brush Company. The plaintiff proposes to start his batteries or let them start themselves, and to let them discharge themselves at their own sweet will; but they proposed, on the contrary, to confine and control—keep the electric current always under the control of a manipulator by means of mechanical devices, and to adjust their current from time to time in such a manner as to enable them to achieve that object. On the whole, he submitted, whatever may be the merit of the general principles which are announced in it, it was a bad patent, and one which did not entitle the patentee to the protection of the Patent Law; and, in fact, the patent itself, he did not hesitate to say, was a mere statement of crude and undeveloped general principles, and of vague generalities, which required experiment, thought, and ingenuity to supply details which would carry them into effect; and he submitted that, on the evidence which would be produced, the Court must come to the conclusion there had been no infringement by these defendants of the plaintiff's so-called patent.

On the same day Sir Frederick Bramwell was the first witness called for the defence. He gave some figures to show the small saving which would be effected by the use of earth return, and the great cost which would be incurred by enlarging the batteries. He drew a diagram to represent the connections of the circuit described in Clark's specification, and put in a copy of the map published as a Supplement to *The Electrician* of January 15th last with the junctions of the feeders marked on it. He explained the model which was made at his instructions to show the working of the defendants' system. He was cross-examined at considerable length by the Attorney-General, and was re-examined by Mr. Finlay on Saturday.

Dr. John Hopkinson was examined by Mr. Wallace, and was cross-examined by the Attorney-General, on Monday, the 7th inst. He was confronted with a favourable report which he had made on the Andrews system of wiring, and with his evidence before a Select Committee in 1879. He was re-examined by Sir Harace Davey, who afterwards examined Mr. Crompton. A number of tables of tests made to refute Prof. Perry's evidence was put in, and showed that with only 1 per cent. above the normal volts a cell rapidly sulphated, hardly any charge going in. Mr. Crompton described an unsuccessful attempt to get an earth return by the Thames at Henley in 1879 or 1880.

On Tuesday Mr. Crompton was cross-examined by the Attorney-General, and was questioned on several statements made by him in Papers and at discussions at scientific societies.

The case was adjourned till Monday next, and it was understood that it will probably conclude on Wednesday. Our abstract, commencing with Sir F. Bramwell's evidence on Friday, last week, will be continued in our next issue. We take this opportunity of giving the grounds for the action.

The plaintiff is the registered owner of Letters Patent No. 3,988 of 1878, and he alleges infringement of the same to have taken place by the use of secondary batteries as reservoirs of electricity in combination with a mode or system of distribution substantially the same as that described in the specification. The modes of distribution complained of are alleged to be (1) the use of the secondary batteries in combination with a number of lamps placed in multiple arc between two main leads; (2) the use of secondary batteries in combination with two or more systems of multiple arc distribution, in which one or more of the main leads are common to two or more of the said systems. The defence is (1) that the plaintiff is not the true and first inventor; (2) that at the date of the issuing of the writ the plaintiff was not the owner of the letters patent; (3) non-admission that the plaintiff is the registered owner; (4) want of utility; (5) invalidity of patent on several grounds, such as improper subject-matter for a patent, want of novelty, non fulfilment of condition by filing a proper description of the invention within six months after the grant of the patent, differences between the provisional and complete specification, anticipations by prior patents and publications.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February* 26, 1892

The Meeting of the National Electric Light Association at Buffalo.—The event of the week has been the meeting of the National Electric Light Association at Buffalo. The Convention began on Tuesday last, and extended over three days. It was somewhat different from previous Conventions in that a vigorous effort was made to transact more business and do more profitable work in the comparatively short space of time. The result was very successful, and it was the most business-like Convention in the history of the Association. The opening Session of Tuesday was devoted to a formal address of welcome from the Mayor of Buffalo and the response from the President of the Association, and a few Committee Reports. In the afternoon work was taken up in earnest, and a Paper by Mr. L. B. Stillwell, "On the Relation of Size and Efficiency in Transformers," was read. In the discussion Prof. Thomson and Wm. Stanley, jun., took prominent part, and a good deal of interesting information was the outcome. The Committee on Safe Wiring then reported, bringing before the Convention some matters which had been referred back to them at the previous Convention at Montreal. Some amendments were introduced, and the rules were then promulgated. Following this were two or three Papers of minor importance. In the evening the subject of the transmission of power came up for discussion. It was opened by Mr. Carl Hering, who discussed the situation as exemplified by the Lauffen-Frankfort transmission of power plant. The speaker was an enthusiastic advocate of the three-phase system. The matter was discussed by half-a-dozen men, chief among them Prof. Elihu Thomson, who expressed himself as believing thoroughly in the coming era of the transmission of power at very high pressures. He suggested that in such cases it would be desirable to place the mains underground, and suggested holding the high-pressure conductors in iron pipes filled with oil. During the discussion a great deal was said about the proposed transmission

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of power from Niagara Falls to Buffalo and Chicago. On the succeeding day the most important feature of the morning session was the Paper by William Stanley, jun., on the alternating motor, with special reference to the new type with which he is experimenting in company with Mr. Kelly. He has succeeded in obtaining some remarkable results with series or shunt-wound motors in connection with condensers and similar devices. In the succeeding discussion Mr. L. B. Stillwell gave considerable account of the results that had been recently obtained from the Tesla two-phase motors. Prof. Elisha Gray, of Chicago, was then introduced, and explained the plans for the Electrical Congress of the World's Columbian Exposition. Inasmuch as no Association or Society can take part in this Congress as an organisation, the matter had comparatively little interest for the majority of the delegates so far as official action was concerned. A Committee was appointed to take Prof. Gray's propositions under consideration, and the succeeding day reported in favour of encouraging the attendance of members at the proposed Congress, but took no more definite or formal action. On Wednesday afternoon some 300 delegates out of the total attendance of nearly 500 made a special trip to Niagara Falls to visit the work of the Cataract Construction Company. The tunnel is now far advanced. The Brush station near the Falls is interesting both from being driven by turbines supplied from Niagara River, and as being one of the few examples of cotton-rope transmission in this part of the country. After the return from Niagara a session was held in the evening, at which the principal feature was a long Paper by Erastus Winan on the financial side of the electric lighting industry There was some further discussion regarding the Electrical Congress at the World's Columbian Exposition; but the Association really took little interest in the matter, although, under proper conditions, it would have been considered very desirable to hold a Summer Convention at Chicago at the time of the Congress. The last day's proceedings were of considerable importance from a practical standpoint. The most striking Papers were two on underground service by Mr. E. A. Leslie and Mr. Craven. The latter gentleman discussed the underground system for the feeders of the Buffalo Street Railway Company. This pair of Papers provoked a good deal of interesting discussion. The afternoon was devoted to executive session, and the election of officers. Mr. J. I. Ayer, of St. Louis, was elected President, and (omitting the Summer Convention) the next meeting of the Association will be in St. Louis in February, 1893.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *March* 1, 1892.

A proposed telephonic installation of considerable extent, and possessing several characteristic features, is at present attracting much attention in Norway. I refer to the Christiania-Bergen trunk line, which will have a length of some 300 miles, and will have to be carried across high and snow-clad mountains. The matter has been referred to the able manager of the Stockholm General Telephone Company, who has great experience of long telephone lines. The Stockholm Company has during the last few years installed several long lines, and has used copper wire. These wires have electrically proved satisfactory, but with rime and snow there have been many mishaps and contacts, so the Company has now adopted bi-metallic wires of double the breaking strength and with a conductivity of 60 per cent. that of pure copper. These wires have, however, hardly been practically tested for a sufficiently long time to form a definite opinion as to their merits, but they seem to answer well. It is thought that a fee of 50 öre (6d.) for three minutes' conversation would enable the Company to pay the shareholders a fair dividend, as well as providing for a sinking fund.

Some very interesting observations were made at the Christiania telegraph station on Saturday and part of Sunday (February 13th and 14th). There was a splendid aurora, and all telegraphing was difficult. Lines usually capable of taking two or three telegrams at the time could only be used for one, and this with constant interruption. This led to endless confusion and complications. The line to Stockholm was almost useless; telegrams handed in at Christiania at noon only reached Stockholm at eleven p.m. The line to Drontheim was even worse; telegrams handed in at Christiania at noon on the Saturday did not reach Drontheim till Sunday morning. On Saturday evening there were four hundred telegrams for Drontheim and the north waiting at Christiania to be despatched.

The State telegraphs in Sweden have during 1891 forwarded 1,849,469 telegrams, against 1,255,329 in 1890, an increase of rather more than 5 per cent. The receipts for telegrams during 1891 amounted to about 1,410,000kr. (£70,500), an increase of about 1½ per cent.

The State telephones in Sweden are not only being continuously extended, but the use of the telephone is also rapidly increasing. On the important Stockholm-Gothenburg line (150 miles), which goes right across Sweden, the number of conversations during 1891 was 74,201, yielding a revenue of £2,100, against £1,025 during 1890, an increase of more than 100 per cent. Parliamentary grants will be asked this year for a number of new lines.

CORRESPONDENCE.

THE CHATHAM ACCIDENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I beg to forward the following facts in connection with the accident:—The foreman of linesmen, named Readwin, had been engaged in replacing a transformer for one which he supposed had been burnt the day before, from the fact that the lamps in the shop refused to light. The same thing occurred with the fresh transformer (that is, the refusal of the lamps to light); and, not finding anything else wrong to account for this, he supposed that there must be a loose connection in the primary work in the house. As a matter of fact, however, one of the service lines had become detached from the main which passes over the roof. Readwin, not knowing this, tried the connection with the fuse box by pulling the wire, which happened to be the one that was still connected to the main, but without removing the fuses. The cause of his receiving a shock was owing to the service lines being placed on a very damp wall, and sufficient moisture having gathered on the surface of the insulation to cause the current to flow from the connection in the fuse box along the surface of the insulation; and Readwin, stepping from the dry board on which he was standing to the damp earth, received the current through his body. The shock immediately drew him up, bringing his whole weight to bear on the wire, until, by falling, he jammed the cable between the back of the fuse box and wall, upon which the damp wall took the current, and so released him. He was conveyed to the hospital, where they detained him, owing to severe burns to his hand and foot.

The young man who died, named Jay, was a salesman in the clothing department of Messrs. J. W. Taylor and Co. Jay, seeing the place filled with smoke owing to the burning of the insulation, and thinking the place was on fire, rushed down stairs with an iron bar in his hand, accompanied by one of the workmen from the tailor's shop. The evidence of this workman at the inquest was that the deceased did not get within striking distance when he (deceased) fell back into his arms. The four doctors in their evidence said that deceased lived for five minutes or more after the accident.

Owing to the fact of all or nearly all the organs being congested and the blood changed to a tarry consistency, this, together with the entire absence of the symptoms of death by a fit, and the fact of the deceased being perfectly healthy up to the time of his death, were the reasons they gave that deceased met his death by electricity; they had never seen a death caused by it. There were no marks of burns on the body. The jury returned a verdict of death by electricity through misadventure, as deceased had been warned by three people not to touch the wires.—Yours, &c.,

G. PEPPER, Secretary,
Chatham, Rochester, and District Electric Lighting Company (Limited),

Rochester, March 9, 1892.

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THE FUNCTION OF A UNIVERSITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Yet one more definition—it is no part of the business of a University to *teach*, says Prof. Fitzgerald, in *Nature* for February 25th. We have now the following as the definitions of the functions of a University:—

1. It should be a mere examining body—*e.g.*, the London University.

2. It is a place for the cultivation of athletics, good breeding and gentlemanly behaviour.

3. At the University there should be taught classics, mathematics, and the pure sciences.

4. The professors at a University should teach *useful* subjects, like mechanical and electrical engineering, medicine, &c., as at Cambridge.

5. The true function of a University is the teaching of *useless* learning.

6. It is no part of the business of a University to *teach*.

Truly, a wide choice of definitions! And seeing that the teaching of applied science which has been developed "at schools, technical colleges, by patent mongers, and the trade," aided "by a lot of savages," has been recently appropriated by the Universities, I have no doubt when these degraded mortals have similarly worked out a system of teaching applied literature, that a seventh definition of the function of a University will be added later on, viz.:—

7. At the University modern languages and literature are studied in such a way as to be of the greatest value to the nation at large.

As Prof. Fitzgerald relegates the teaching of things useful to the class of pariahs mentioned above, perhaps he will tell us whether he raises the study of mechanical and electrical engineering to the lofty position of uselessness, or whether he utterly condemns the appeal that is now being widely made—made even to technical teachers—for aid in the establishment of engineering laboratories at a University which has recently thought that the best place to obtain an assistant was a London technical college.

He thinks that students, "if they are so ill prepared that they have not acquired the art of learning, should go to a College, . . " and not to the University. I presume, then, that they ought to go, for example, to the Colleges of Trinity or St. John, but not to Cambridge; or to the Colleges of Balliol or Christ's, but on no account to Oxford. Perhaps this somewhat conflicting advice is the result of Prof. Fitzgerald's studying literature "for its own sake," as contrasted with studying language for the sense it conveys. Examples were recently given in a leader in one of the daily papers, illustrating that the public utterances of some of the most prominent advocates of the compulsory teaching of Greek conclusively proved that it was not to improve their English that they had studied the classics.

In the same lucid way Prof. Fitzgerald adds, "The Bible produced very little effect until it was read in translations, and the danger of a pagan revival, if ancient literature were studied without the obstruction of difficult languages, is the best reason for insisting on these languages in a Christian University." Surely a man of his wide intellectual power cannot mean that the general reading of the Bible, which became possible after it was translated into modern languages, is to be deplored. But neither, on the other hand, can he mean that the incalculable benefit that has resulted from the translation of the Bible into the vulgar tongue, is an argument for the suppression of free translation. On whichever horn of his own dilemma he decides to pose himself, I, at any rate, have no sympathy with the Roman Catholic dogma, that good comes from making the knowledge of the truth difficult of attainment by the world at large.

He chides me with forgetting the debt electrical science owes to those who studied it while useless. Does the statement that one *volt* sends one *ampere*—that is, one *coulomb* per second—through one *ohm* look as if the practical engineer had forgotten the labours of Volta, of Ampère, of Coulomb, and of Ohm? Indeed, is not Prof. Fitzgerald forgetting the deep debt of gratitude the theoretical study of electricity owes to its practical applications? The late Prof. Fleeming Jenkin, a professor at a University bear in mind, wrote in 1873, "In England, at the present time, it may almost be said that there are two sciences of electricity—one that is taught in ordinary text-books, and the other a sort of floating science, known more or less perfectly to practical electricians. . . A student might have mastered De la Rive's large and valuable treatise, and yet feel as if in an unknown country and listening to an unknown tongue in the company of practical men. It is also not a little curious that the science known to the practical man was so to speak, more scientific than the science of the text books.'

While there are University Professors like Thomson, Hertz, and Fitzgerald what matters it whether we call them the *teachers* or ourselves the *learners*? When the work they are now carrying on may be of incalculable service to the practical man in the future, of what avail is it to discuss whether it is to-day *useful* or *useless*? For such labours I have too profound a respect and admiration to "sneer" at what I hold to be the true function of the University.

But equally worthy of respect, do I think, is the *teacher* in a *school* of engineering—that is, one who aims at presenting useful knowledge, and the methods for extending it, in such a form as to be most easily grasped by those who intend to devote their lives to engineering.

My friend Prof. Fitzgerald and I are, at any rate, wholly in accord on one important point, urged in my recent inaugural address, viz., that it is the special function of the technical school to teach *useful* knowledge.—Yours, &c.,

W. E. AYRTON.

[Prof. Fitzgerald's letter to *Nature*, to which Prof. Ayrton alludes, was reproduced on p. 450 of our last issue.—ED. *E*.]

CABLE TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR. Would you kindly allow me space in your columns to point out the fact that a cable transformer, consisting of a stranded iron rope surrounded with two separate windings of copper wire, similar to the present Siemens' cable transformer, was patented by me in France on April 3, 1886, Patent No. 175,242.—Yours, &c.,

C. E. L. BROWN.

Baden, March 7, 1892.

ELECTRIC LIGHT CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to the correspondence opened in your journal recently on the quality and durability of vulcanised rubber cables, there are several points that have not been touched upon, yet are of no mean importance in guiding the user to secure a good insulation. Foremost among these is the separator, or intermediate covering between the pure and vulcanised rubber or jacket. The true function of the separator seems scarcely known or appreciated by the younger firms in the cable business, as it is often left out altogether; even many of the older companies seem to have forgotten, or to ignore, the importance attached to this covering in the old telegraph days.

The separator could consist of a non-vulcanising rubber compound, its object being to act as a sort of trap to prevent the sulphur penetrating to the pure rubber, and thence to the wire, which, if not prevented, is sure to bring on chemical action and decomposition. The separator made in this way is only cured on the outer surface by absorption of sulphur from the jacket, and should remain comparatively soft. All important cables, at least, should have such a separator. In heavy cables this covering need only be thin in proportion to the vulcanised covering. A good criterion that the sulphur has not penetrated is that the tinned wires should remain perfectly bright.

Another point seldom touched upon, but which should be seen to, is that the wire is perfectly concentric with the covering. I have seen examples recently where in places there was little more insulation than what the cloth tape afforded.

Lastly, from a life-long experience in every detail of manufacture and testing all descriptions of insulated conductors, I have more confidence in coverings that have been put on in

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two or more layers than those that have one covering only of equal total thickness. No matter what care is taken in the manufacture and preparation of materials, and how perfect the machinery, faults will happen, and they are more easily detected during the manufacture in two or more layers than one thick covering, and are less likely to be as serious or do so much harm.

Perhaps the points I have raised are more properly questions for manufacturers to settle for themselves; but their discussion, and the proper ventilation of various opinions, is bound to be of benefit to the trade at large.—Yours, &c.,

JAMES CONNOLLY,
Electrician to the International Okonite Company (Limited).

Newton Electric Works,
Manchester, March 8, 1892.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—Our advertisement columns contain an announcement that tenders are invited for lighting by electricity the buildings and grounds of the International Exhibition, to be held in the Isle of Man during the months of July, August, and September. Specifications and full particulars may be obtained from the Secretary.

———— Tenders are required for maintaining the electric light installation at Falcon Cliff Grounds, Douglas, Isle of Man, full particulars of which are to be obtained from Mr. Rowe, secretary, Cliff Company, Douglas.

SALE BY AUCTION.—Messrs. Weatherall and Green announce in our advertisement columns that they will sell by auction, on the 28th inst., some valuable freehold and leasehold property at the London Docks.

ELECTRICAL ENGINEERING CORPORATION (LIMITED).—We regret to learn from Mr. F. W. Pixley, the receiver and manager of the estate of the Electrical Engineering Corporation (Limited), that it is unlikely he will be able to pay the debenture holders 20s. in the pound, and that therefore nothing can possibly come into his hands for the unsecured creditors.

INSTITUTE OF MEDICAL ELECTRICITY (LIMITED), IN LIQUIDATION.—We understand that a dividend in this matter will shortly be declared.

MAXIM-WESTON ELECTRIC COMPANY, LIMITED (IN LIQUIDATION).—Meetings of the shareholders of the two Maxim-Weston Companies will be held, for the purpose of receiving accounts of the windings-up at Cannon-street Hotel on April 8th—in the case of the first liquidation at 12, and in the case of the second Company at 12:30.

MESSRS. MATHER AND PLATT.—Some considerable improvements have recently been effected at the central station, Manchester, by the adoption of the electric light, for which Messrs. Mather and Platt have supplied the engines and dynamos, Messrs. Galloway supplying the boilers. The installation consists of 40 arc lights of 2,000 c.p., each distributed over the platforms and approaches. The offices, &c., are lit by means of 16 c.p. incandescent lamps, and the public rooms are supplied with handsome electroliers. The generating plant is conveniently placed beneath the Viaduct, from which position power is supplied by two powerful compound engines; and the whole plant of engines, boilers, and Edison-Hopkinson dynamos is in duplicate, with specially-designed arrangements and every precaution to guard against failure. The Cheshire Lines Committee are, we understand, so gratified with the result of this installation, that they have commissioned Messrs. Mather and Platt to light the whole of their extensive goods depôt, which will require, it is estimated, 76 1,000 c.p. and 10 2,000 c.p. arc lamps, and 65 16 c.p. incandescents, which are expected will be at work in the spring, and will result in the entire discarding of the use of gas for the electric light. The general arrangement of the lighting has been supervised by Mr. W. S. Scott, general engineer of the Cheshire Lines Committee, and is undoubtedly one of the most important railway installations in the Kingdom.

MCWHIRTER, FERGUSON AND CO.—This firm has been entrusted by Messrs. Edward Lloyd (Limited) with the lighting of their large paper mills at Sittingbourne, where the new mill just finished is entirely lighted by electricity. Two Faraday dynamos of the latest type have been put in, driven by a 160 H.P. engine. The installation is, we understand, giving satisfaction; and, as a consequence, suggestions have been put forward for lighting the town of Sittingbourne by electricity.

DOMESTIC ELECTRICITY.—Messrs. Crompton and Company and the General Electric Company, have added to their exhibits at the Crystal Palace Exhibition a new department, and what may be termed a new departure. They have fitted up a room especially to show the various applications of electricity for domestic purposes. The room is situate near the High Level entrance, and adjoins the stand of *The Electrician* Company. Mr. H. J. Dowsing acts as demonstrator, and explains to the public visiting the room the advantages of the domestic machinery on view, which consists of small electric pumps, fans for ventilators, spray diffusers, knife cleaners, boot cleaners, coffee grinders, electric kettles, fry-pans, flat-irons, curling tongs, foot-warmers, and other apparatus. The process of cooking by electrical apparatus is shown, including the frying of cutlets, boiling and frying potatoes, and other interesting experiments. A new form of electric heating apparatus is also on view. The apparatus shown is only of small size, but larger apparatus is now being made. There can be no doubt that this additional room will be well patronised by visitors to the Exhibition, and will probably do more to popularise the use of electricity for domestic purposes on what may be termed a small scale than anything else shown at the Crystal Palace. The idea is altogether a good one, and we would offer the suggestion that it be made a permanent exhibit at the Crystal Palace, and also that a similar exhibit be shown at the various Exhibitions held throughout the country; care, of course, being taken to point out that, at any rate for the present, such electrical luxuries are only obtainable by those possessing ample means.

PERSONAL.—Mr. L. Alwyn, who was till lately engineer in charge of Messrs. Laing, Wharton and Down's City installation works, has been appointed by the Brush Electrical Engineering Company (Limited) their sole City agent, at 53, Queen Victoria-street, in succession to Messrs. Bate and Webb Watts.

ALUMINIUM.—A note in the *Financial News* of Tuesday announces that an American Aluminium Company has started an experimental plant in Philadelphia, working on the Broadwell patent. As is usual where aluminium is the subject, all sorts of wild statements are made by the representatives of the Company, the wildest probably being that under this system aluminium can be produced at a halfpenny per pound with profit. Our readers may remember that some time back a man named Mason, trading under the style of the Aluminium Electric Company (amongst others), of Great Sutton-street, Clerkenwell, E.C., issued a circular, bearing all the evidence of genuineness, announcing that the Company with which he was associated was able to manufacture aluminium at 2s. per pound. This gentleman has just been relegated to one of Her Majesty's gaols for 18 months with hard labour for swindles in connection with this and other electrical matters. A weekly paper, reporting his trial at the Clerkenwell Sessions, says that he was indicted for having obtained under false pretences "a carsaw volt-meter and a gravity animator" from one firm, "three animators" from another, besides other curious instruments.

THE PARA RUBBER MARKET.—The following is from the *Financial News*, March 5:—"The rubber market is again advancing. Fine Para, which has recently been bought by dealers at 2s. 8d. per lb., less 2½ per cent. discount for cash, was yesterday quoted at 2s. 10d. for spot and 2s. 10½d. for April delivery. May arrival is not offered, though we understand that large orders are in the market at 2s. 11¼d. Para cables of yesterday quote fine at 2s. 11¼d. delivered in Liverpool, while the American Market sympathises, prices being now quoted at 71c. to 72c. per lb. America has been a large buyer of Para sorts during January and February, which has reduced supplies all round. The new crop of Para rubber does not begin to come in, even in small quantities, until August; and it is generally said that prices, especially in the case of fine Para, will probably experience an advance. Baron Vianna's holdings are said to have been disposed of, and are consequently no longer a dead weight on the market."

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

February 11, 1892.

2,646. L. LARRANAGA. London. Improvements in telephonic transmitters.

2,652. F. KLOSTERMANN. London. Improved regulator for voltaic arc lamps.

2,653. H. E. LANGLEY. London. Improvements connected with electrically operated coin-freed apparatus.

2,690. H. TIPPING. London. Improvements in electric arc lamps.

2,722. A. L. SHEPARD. London. Improvements in electric switches.

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2,724. A. GRIMM. London. Improvements in electro-therapeutical apparatus.
2,727. O. IMRAY. London. Improvements in telephone receivers. (F. Gross, Canada.)
2,733. A. PIAT. London. Improvements in and relating to the driving and controlling of riveting, shearing, punching, and other machines by electricity.

February 12, 1892.

2,743. A. S. FIELD. Wimbledon. The application of electricity to a scientific puzzle.
2,744. B. HOFFMAN. Manchester. Improvements in telephonic instruments.
2,748. R. J. CROWLEY. Queenstown. Electro-heliograph suitable for interastral communication.
2,762. W. P. THOMPSON. Liverpool. Improvements in or relating to electrical signal apparatus for indicating the position of railway switches or points. (P. Schwenke, Germany.)
2,775. R. A. P. TAUNTON. London. Improvements in ozonizing or electrifying atmospheric air or other gases.
2,784. J. C. NEWBURN, London. Improvements in or relating to sockets and switches for incandescent lamps.
2,785. J. C. NEWBURN, London. Improvements in incandescent electric lamps. (D. H. Piffard, United States.)
2,791. W. COBB, Junior, and W. D. WILDER, London. An improved time-registering device for electric currents.

February 13, 1892.

2,831. J. OULTON and J. EDMONDSON, Halifax. Improvements in apparatus for the driving of chronometric balances and pendulums for electricity meters.

February 15, 1892.

2,913. G. NAHNSEN. Berlin. Improvements in the electro-metallurgic extraction of zinc.
2,920. J. W. KNAUSE. London. An improved pole for supporting telegraph wires and the like.

February 16, 1892.

2,981. P. A. CRAVEN. Wimbledon. Improvements in electro-medical appliances.
2,992. G. D. BURTON. London. Improvements in systems of electrical distribution of heating currents.
2,996. F. HOYER. Liverpool. An improvement in the construction of electric incandescent lamps.
3,030. H. H. LAKE. London. Improvements in and relating to the lighting of railway vehicles by electricity, and to apparatus therefor. (The Consolidated Car-Heating Company, United States).

February 17, 1892.

3,112. S. Z. DE FERRANTI. London. Improvements in electric meters.
3,113. S. Z. DE FERRANTI. London. Improvements in generating, transmitting and utilising currents of high tension, and in apparatus used for these purposes.
3,114. C. THOMPSON. London. Improvements in electrical primary batteries.
3,120. P. H. BERTRAND. London. Improvements relating to galvano plastics or the electro-deposition of metal.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

2,016. HUTCHINSON. Electrically propelled vehicles.
4,588. MUNRO. Electric lamps.
5,045. SENNETT. Transformer aspirator.
5,318. BOARDMAN and FAIRFAX. Arc lamps.
5,329. BRISTOL. Electric safety lamps.
5,350. HARPER. Electrical dynamo machines.
5,404. CLIFT. Electric, &c., lamps.
5,802. MCGEOCH (W. and A. J.). Incandescent electric lamps.
20,699. THATCHER and DEVEREUX. Electric indicator.
2,785. PYKE and HARRIS. Dynamo electric machines.
3,748. MCLEAN. Electrical insulators.
4,660. HOWARD. Heating and welding by electric arc.
5,712. PITT (Davidson). Insulating electrical conductors.
5,713. PITT (Davidson). Insulating electrical conductors.
5,714. PITT (Davidson). Insulating electrical conductors.
5,835. JONES. Electrical measuring instruments.
5,918. HARRIS and POWER. Electric batteries.
6,372. PARLEY. Electric time calls.
12,982. WETHERFIELD. Electric time check.
13,912. PARKER and OTHERS. Electric circuits.
18,493. ELKINGTON. (Compania Electricista contra Incendios.) Electric fire alarms.
18,348. PARKER and OTHERS. Distribution of electricity.
21,728. WATERHOUSE. Electric arc lamps.
22,482. LAKE (Weston.) Voltaic cells.
22,820. FURTADO and OTHERS. Telephones.

1892.

106. STURGE. Electric switches.

COMPANIES' MEETINGS & REPORTS.

Kensington and Knightsbridge Electric Lighting Company (Limited).

The general meeting of this Company was held yesterday, at No. 1, Great George-street, Westminster; Mr. Granville R. Ryder, presiding.

The SECRETARY (Mr. R. S. Erskine) read the notice convening the meeting and the minutes of the previous meeting, which were confirmed and signed as correct.

The report and statement of accounts were taken as read.

The CHAIRMAN said: Gentlemen, as this is a very small meeting I do not think that it is necessary for me to trouble you with many remarks. It will be seen that the Company has made very substantial progress. During the year we have jumped from having 25,535 lamps to 38,408, or an increase of 12,873. During the year the number of houses and shops connected with the system has increased from 291 on December 31, 1890, to 436 on December 31, 1891. With regard to the accounts you will observe that during last year there has been an increase in capital account of £21,780, namely, £13,350, in Preference shares, and £7,930 in Four and a-Half per Cent. Debentures. This increase of capital has been laid out in this way:—in mains and improvements of mains, £8,000; in plant, £7,508; in batteries, £4,200; in instruments and meters, £1,200; and in buildings, £1,000. With regard to the renewal fund, that stood last year at £1,398 odd, and it has been increased this year to £1,713. A satisfactory feature in the accounts is that the production of electricity, which last year cost £2,915, is this year £4,067; and whereas last year with nearly £3,000 spent on its production it only produced a profit of £1,404, this year with an increase of only about £1,000 we have increased our profit to £4,381. Therefore the increased cost has been one-fourth and the increase of profit two-thirds. I think, gentlemen, we may fairly say that, taking the accounts generally, they are satisfactory. We could have wished that we had had more business. That is the only point which is rather disappointing. We expected to get out 40,000 lamps, whereas we have only reached 38,400. Since the latter figure was reached the number has increased by 1,000, but still we have not reached 40,000. What is quite clear from these figures is that there is a very good future for the Company in respect of profits. This is exemplified by figures which Mr. Erskine has worked out for me, showing that the price of the unit we charge is 8d., but it only cost us this year 5½d., leaving a profit of 2½d.; whereas last year the cost was 6½d. out of the 8d., so that we have got the advantage of 1d. out of every 8d. as compared with the preceding year. There is one other point which I should mention, and that is with regard to the gross revenue to be derived from each lamp. Last year I was able to put it at 10s., but we find now that it is not so much as that, being not more than 9s. per lamp. I do not think that we need be dissatisfied with the result, because everything that tends to cheapen the electric light is for our interest and advantage, for it is much more likely that the electric light will become the light of the future if it can be cheapened in every possible way. With regard to capital account it is the object of the Directors to keep it down as much as possible. At the same time in a Company of this kind it is impossible to progress without constantly getting more capital. The only thing to be observed is to see that it is employed in such a way as to yield us a profit. As far as the current year is concerned the capital expenditure will be about £16,000. He concluded by moving the adoption of the report and accounts.

Mr. G. H. HOPKINSON seconded the motion.

The CHAIRMAN, in reply to questions by shareholders, said that the form of their accounts was prescribed by their auditors. He thought that they had made a very good start. In a business of this kind they could not expect to jump into a dividend-paying position all at once. They had no doubt advanced rather slowly last year, but every day there were fresh installations for houses and shops coming in. He did not think that the salaries paid to their staff were too high, considering that they had two branches which had to be conducted by scientific men.

Referring to the action "Lane Fox *v.* The Kensington and Knightsbridge Electric Lighting Company, Limited," Mr. R. W. WALLACE stated, in order to allay any fears shareholders might have as to the ultimate cost of the action, that this would be borne only partly by this Company.

The motion was then agreed to.

The CHAIRMAN next moved the payment of a dividend on the ordinary shares at the rate of 2 per cent. for the year.

Mr. R. W. WALLACE seconded the motion, which was agreed to *nem. con.*

Mr. A. S. Bolton and Sir Frederick J. Bramwell, Bart., were unanimously re-elected to their seats at the Board. The latter, in returning thanks, wished to remind any shareholders who might think that the salaries paid by the Company to its staff were too high, that the business they were pursuing was one of great difficulty, requiring the greatest care and men of ability and trustworthiness. Considering the services rendered, he thought that the salaries were extremely small indeed. As a Director he was quite content to go without his fees until the Company could afford to pay them, but he was not content to employ men of ability and not adequately remunerate them.

The auditors, Messrs. Lovelock, H. W. Whiffin and Dickinson, were unanimously re-appointed.

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On the motion of Mr. SCHWAN, seconded by a SHAREHOLDER, a vote of thanks to the Chairman and Directors was cordially passed.

The CHAIRMAN, having briefly expressed his acknowledgments, the proceedings terminated.

The following is the report of the Directors for the period ending December 31, 1891, presented at the above meeting :—

The Company's mains, which extended for a length of 10 miles in the previous year, have been increased during the year 1891 to 12½ miles. During the year the number of houses and shops connected with the system has increased from 291 on the 31st December, 1890, to 436 on the 31st December, 1891 ; while the number of lamps, calculated on the usual basis of eight c.p., has increased from 25,535 to 38,408.

The plant at the stations has been worked at a greatly increased rate of efficiency, especially during the last half-year, and further improvement in this respect is still being made. Provision has been made at Kensington Court for fixing a new boiler, and at Chapel-place three new engines have been added during the year to meet the rapid increase in the demand at this station. The funds required by the Company for extensions during the past year have been raised by the issue of Four and a-Half per Cent. Debentures, and it has not been found necessary to issue any of the Second Preference Shares authorised at the last Meeting.

The dividend on the Six per Cent. Preference Shares was duly paid to 30th June, 1891, and out of the balance standing to the credit of the net revenue for the year 1891, £3,810. 11s. 3d., the sum of £1,462. 10s. has been appropriated for the payment of the Preference dividend to that date, leaving £2,348. 1s. 3d., out of which it is proposed to pay a dividend on the ordinary shares at the rate of 2 per cent. for the year, carrying forward £848. 1s. 3d. to the next account.

In accordance with the Articles of Association, Mr. A. S. Bolton and Sir Frederick J. Bramwell, Bart., F.R.S., retire from the Directorship, and, being eligible, offer themselves for re-election. The Auditors, Messrs. Lovelock, H. W. Whiffin and Dickinson, offer themselves for re-election.

Liverpool Electric Supply Company (Limited).

The ninth annual ordinary general meeting of the shareholders of this Company was held on Friday at Liverpool ; Mr. A. H. Holme, Chairman of the Company, presiding.

The report of the Directors on the working for 1891 stated that the amount of net profit available for dividend, including the balance brought forward from last year, was £7,866. 14s. 9d., out of which they recommended payment of a dividend of 4½ per cent. per annum, absorbing £6,580, adding £500 to the reserve fund, and carrying forward the balance to next year's account. They considered the time had arrived when, in addition to writing off depreciation, a provision should be made for the renewal of mains and plant which might be necessary in the future, and they had, therefore, initiated a renewal fund, to the credit of which they had passed a sum of £1,500. The expenditure on capital account during the year (including a proportionate charge for general expenses) had been £17,122. The demand for electricity continued to increase, and the number of lamps connected with the Company's supply mains on December 31, 1891, was equivalent to 14,966 lamps of 16 c.p. each. During the year Provisional Orders had been granted to the Company by the Board of Trade for an additional area in Liverpool, including London-road, Prince's-road, and Prince's Park, and also for an area under the Toxteth Park Local Authority, including Sefton Park and the adjacent residential district. Both these Provisional Orders were for the full statutory term of 42 years. The Directors had obtained the consent of the Watch Committee, subject to confirmation by the City Council, to a Provisional Order under which the date for compulsory purchase on the terms of the Electric Lighting Acts of the Company's undertaking authorised by the Provisional Order of 1889 was postponed from 21 to 42 years ; the Corporation to have the option of taking over the Company's supply business in the City of Liverpool as a going concern after December 31, 1897, at a price to be fixed by arbitration, as in the case of property taken under the Lands Clauses Consolidation Acts.

The CHAIRMAN, in proposing the adoption of the report and balance-sheet, proceeded to explain the position of the Company in further detail. He first observed that their business had since the previous year very materially increased, and that their prospects also were exceedingly good. People were beginning to appreciate the electric light, and he was glad to say that with increasing business they had made increased profits. The dividend proposed had been fairly earned. Some shareholders might say that they should have declared a dividend of 5 per cent., but they were anxious to do nothing which would injure the future of the Company. With regard to the renewal fund, it was certain that the wires did deteriorate to some extent, although not through the passage of electricity ; and, besides that, the advance of electric science might make necessary improvements which at present they could not foresee. The expenditure on capital account was due more particularly to the extension along Rodney-street and Mount-pleasant, and it had been fully justified. Last year the number of lamps was 11,750 ; this year the number was 14,966 ; and at present they had orders which would increase the total to 16,900, which was, he thought, very satisfactory. As to the Provisional Order for the additional area, it was for that area that they were making a call of 10s. a share. That would bring in £17,000, which would be nearly all absorbed in an extension proceeding in one direction through Abercrombie-square and along Bedford-street to Prince's-road, and in the other towards University College and London-road. In all those districts they had considerable promises from people anxious to use their light, and he thought that next year the shareholders would say that the expenditure was justifiable. He came next to a matter of great importance, and one which had cost the Directors some anxiety. After somewhat protracted negotiations with the Corporation through the Watch Committee, they had come to an arrangement, which, the previous day, was confirmed by the Council, in consequence of which the shareholders might consider that for 42 years their undertaking was their own property, and could not be taken over by the Corporation except on terms which were satisfactory to the Company, and would give them a fair return for the money they had expended. It was one of those happy agreements by which everyone benefited mutually, for by it their consumers got electricity at a much lower price than they could have obtained it otherwise. In various matters the Corporation were really very hard people to deal with. They had made the Company pay a large sum for reinstating the streets. He hoped, however, that the Corporation would follow the example of other cities. In Manchester, Birmingham, London, and even in Bootle, town halls and public buildings were lighted by electricity, and it was to some extent scandalous that the Liverpool Town Hall should continue to be lighted by gas. At the same time, the Corporation had instructed their engineer to report on the matter, and no doubt the effect would be that the Company would increase its business to that extent.

Mr. D. DE YBARRONDO seconded the motion.

In reply to questions, the CHAIRMAN said the dividend would be paid free of income-tax. The patent for the lamps expired next year, and they would then be produced for about 1s. 3d. a piece, instead of from 4s. to 5s. as at present. The arrangement with the Corporation was that all profits over 7 per cent. were to be divided equally between the shareholders and consumers.

The report having been passed, and the retiring Directors, Messrs. A. H. Holme and D. de Ybarrondo, and the auditor, Mr. W. L. Jackson, re-elected, it was decided to increase the remuneration of the Directors from £300 to 400 guineas.

The CHAIRMAN afterwards submitted a resolution approving of the Provisional Order now being promoted by the Company before the Board of Trade, and accepting the amendments agreed upon between the Company and the Corporation, which was seconded by Sir D. RADCLIFFE, and agreed to.

A vote of thanks to the Chairman concluded the proceedings.

Taunton Electric Lighting Company (Limited).

The fifth annual general meeting of the shareholders of this Company was held on the 29th ult. at Taunton ; Mr. W. H. Fowler, Chairman of the Company, presided.

The CHAIRMAN, in moving the adoption of the balance-sheet, expressed great regret at meeting the shareholders under such unfavourable circumstances. He had to report a deficit. He attributed it mainly to the fact that the public had not supported the Company to the extent which the Directors had been led to expect would have been the case when they removed to the larger depôt. The system adopted by the Company of charging the consumers so much per lamp instead of by meter had not been successful. As the consumers paid a certain sum per lamp, however long they burnt it, they were not so economical as they would be if they paid by meter ; and also the system of charging which was adopted was not satisfactory to the consumers, for they paid for the light whether they used it or not. It was known that some consumers used the electric light for much longer hours than they would if they had gas.

Mr. POTTER seconded the motion for the adoption of the balance-sheet, and it was carried.

The retiring Directors, Messrs. Bale, A. Chapman, and W. Potter, having been re-elected, the question of the disposal of the works to the Town Council was brought up ; but the matter was left entirely to the Directors to do the best they could for the shareholders. Complete confidence was expressed in the Directors, to whom a vote of thanks was accorded for pa t services.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed p r-ticulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *and in other parts of that book.*]

BOARDMAN'S ELECTRIC SUN LAMP PATENTS (LIMITED).—This Company was registered on March 5, 1892, with a capital of £10,000, in £5 shares, by C. E. Baker, 22, Great George-street, Westminster, S.W. The objects are to carry on the business of an electric light, power, and manufacturing company in all its branches ; to apply for, purchase, or otherwise acquire, patent rights and privileges relating to patent rights connected with the use of electric light, power, or force ; to enter into contracts for the supply of electric power for lighting, locomotion, electro-plating, or deposition, or any other purpose ; and to carry on the business of manufacturers of, and dealers in, all or any kinds of electrical apparatus and appliances, whether used or to be used in connection with electric lighting, locomotion, or other purposes. Registered without Articles of Association.

HOBART TRAMWAY COMPANY (LIMITED).—This Company was registered on March 4, 1892, with a capital of £105,000, in £1 shares, by Messrs. Linklater, Hackwood, Addison, and Brown, 2, Bond-court, Walbrook, E.C. The objects are to apply for, obtain, accept, adopt, and carry into effect any Act of Parliament, Imperial or Colonial, Provisional Order, concession, or contract for the establishment, construction, maintenance, and working of tramways in Hobart, Tasmania, or elsewhere : to take over the existing tramway at Hobart ; to construct, equip, maintain, and work, by means of electricity or in any other manner, any tramways; to carry

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on at Hobart, or in any part of Tasmania and elsewhere, the business of an electric light company in all its branches, and in particular to form centres at which electric power may be generated and accumulated, and from which the same may be distributed by means of wires or other conductors of electricity, for the purpose of lighting public buildings, houses, streets, &c.; to enter into contracts for any period for the supply of electric force, and to supply, fix, and maintain all electric generators, batteries (primary or secondary), lamps, engines, motors, converters, meters, and other electric appliances. (The tramways to be taken over are authorised by special Act of Parliament of Tasmania, 48 Vic., as amended by 53 Vic. and 55 Vic., and it is proposed to work them by electricity by means of overhead conductors.) The number of Directors is not to be less than one nor more than seven, the first being Sir Edward N. C. Braddon, K.C.M.G., Agent-General of Tasmania (Chairman), Charles Barclay, Alfred Mattei, LL.D., J. C. Bellamy, J. W. Syme, and C. H. Grant, M.I.C.E. Qualification, the holding of 100 £1 shares. Remuneration: £100 per annum for each Director, and £50 additional per annum for the Chairman. In addition to the above, whenever a 10 per cent. dividend has been paid, the Directors are entitled to 5 per cent. of the net profits above the said 10 per cent. Offices: College Hill-chambers, Cannon-street, London, E.C. [Further reference is made to this Company in "City Notes"]

NEWALL AND COMPANY (LIMITED).—This Company was registered on the 4th inst., with a capital of £10,000 in £10 shares, with objects, among others, to carry on the business of mechanical, marine, gas, and electrical engineers, machine and engineering tool makers, manufacturers of locomotive, traction and other engines, boiler makers, &c.

MISCELLANEOUS COMPANIES.—The following Companies, proposing to deal more or less with electricity, have been registered:—

Birmingham Art Metal Company (Limited); capital £5,000.
Leen Valley Land Company (Limited); capital £1,000.
Willoughby and Co. (Limited); capital £2,000.

ANDREWS AND PREECE (LIMITED).—The first annual return of the above-named Company made up to December 31, 1891, was filed on February 22, 1892. The Company was registered on April 1, 1890 with a capital of £25,000, divided into 300 deferred and 22,000 ordinary shares. At the time of making up 300 deferred and 408 ordinary shares had been taken up, of which the deferred shares had been issued as fully paid. Upon the 408 ordinary shares the full amount had been called, resulting in the payment of £4,015, and leaving £65 in arrears. The second return of the same Company, made up to February 11, 1892, was also filed on February 22. No change has been made. The principal shareholders are Thomas R. Andrews, with 200 deferred and 187 ordinary shares, and Thomas Preece, with 100 deferred and 46 ordinary shares.

CARBON ELECTRIC (LIMITED).—The registered offices of the above-named Company have been removed from 24, Moorgate-street, London, E.C., to 33, Old Broad-street, London, E.C. This Company was registered on April 15, 1891, with a capital of £20,000, in 4,000 shares of £5 each (of which 3,000 were Preference and 1,000 Deferred. No statutory return has been filed (although such return ought to be filed within five months of registration), and no agreements for the purchase of the works alluded to above, or any other, have been filed.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).- The annual return of the above-named Company, made up to February 24, 1892 was filed on March 4, 1892. The Company has a nominal capital of £220,000, divided into 16,000 Ordinary and 6,000 Preference shares of £10 each, of which all have been taken up, the full amount called, and all calls (£220,000) paid.

BRITISH INSULATED WIRE COMPANY (LIMITED).—The first annual return of the above-named Company, made up to February 24, 1892, was filed on March 5, 1892. The Company was registered on October 20, 1890, with a capital of £60,000, divided into 300 Founders', 3,950 Preference, 3,450 Ordinary A, and 4,300 Ordinary B shares of £5 each. By a special resolution in general meeting, passed June 23, 1891, the capital was raised to £110,000 by the addition of 6,000 Ordinary A shares and 4,000 Ordinary B shares of £5 each. By an agreement made August 7, 1891, with S. Z. de Ferranti, it was agreed that the vendor should sell and the Company should purchase the following patents:—No. 12,505, of 1888, for joints in electric mains; No. 16,237, of 1889, for improvements in electric mains; No. 2,315, of 1888, for improvements in electric mains; No. 15,251 of 1885, for improved means for distributing electric energy; and No. 12,418 of 1887, for carrying electric energy: subject, however, to an agreement dated August 2, 1887, between Sir Coutts Lindsay and Co. (Limited) and S. Z. de Ferranti, the benefits of which are now vested in the London Electric Supply Corporation (Limited), the vendor only to sell his interest in the last two mentioned patents, and that part only which referred to mains or conductors to be used for carrying electric energy. The consideration for the said sale was to be the sum of £26,305, to be satisfied as follows, viz.:—£6,210 in cash, and the balance by the issue, to the vendor or his nominees, 475 Preference, numbered 2,826 to 3,300 inclusive, 475 Ordinary A, numbered 7,001 to 7,475 inclusive, 3,050 Ordinary B shares, numbered 16,001 to 19,050 inclusive, and 19 Founders' shares, numbered 282 to 300 inclusive. At the time of making up (February 24, 1892), 16,522 shares had been taken up. Upon 300 Founders', 3,250 Preference, 2,552 Ordinary A, and 7,018 Ordinary B shares, the full amount has been called, and upon 400 Preference, and 3,002 Ordinary A shares, £1. 5s. has been called, resulting in the payment of £69,015, and leaving £837. 10s. in arrears. The principal shareholders are:—W. M. Brigg, of Keighley (51 Founders', 539 Preference, 299 Ordinary A, and 1,109 Ordinary B), Messrs. Felten and Guilleaume, of Mulheim-Rhine, Germany (20 Founders', 500 Preference, and 1,000 Ordinary A), and Sebastian Z. de Ferranti, of Charterhouse-square, London (75 Founders', 275 Preference, 175 Ordinary A, and 3,550 Ordinary B shares).

ELECTRIC TRAM CAR SYNDICATE (LIMITED).—The annual return of the above-named Company was made up to and filed on January 12, 1892. The Company was registered on April 26, 1889, with a capital of £20,000, in £10 shares. At the time of making up, 1,814 shares had been taken up, of which 1,300 had been issued as fully paid, in accordance with the above agreement. Upon the remaining 514 the full amount had been called, resulting in the payment of £5,130, and leaving £10 unpaid. The following notice was filed on March 2, 1892. At a special general meeting of the members of the above-named Company, duly convened, and held at 31, Lombard-street, E.C., on February 11, 1892, the following special resolutions were passed, and at a subsequent special general meeting were confirmed:—"1. That the capital of the Company be increased to £25,000 by the creation of 500 new ordinary shares of £10 each." "2. That the Directors be and are hereby authorised to issue the said 500 shares to such persons, and to be paid for by such instalments, or otherwise, as they think fit, and without being bound to offer the same, or any of them, to existing members of the Company." The legal forms for the increase of capital referred to above were also filed on March 2, 1892.

WEYMERSCH ELECTRIC BATTERY SYNDICATE (LIMITED).—The first annual return of the above-named Company, made up to February 11, 1892, was filed on the following day. The Company was registered on November 28, 1890, with a capital of £20,000 in £5 shares. At the time of making-up, 3,807 shares had been taken up, of which 300 had been issued as fully paid. Upon 200 of the remainder the full amount has been called, and upon 600 £4 per share has been called, while upon the remaining seven, no calls have been made. The total paid amounts to £2,800.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED). — An interim dividend has been declared of 3s. per share, being at the rate of 6 per cent. per annum, free of income tax, for the quarter ended December 31, 1891, payable on the 25th inst. The books of the Company will be closed from the 18th to 24th inst. inclusive.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).— The traffic receipts for the week ended March 6th were £893, as against £732 in the corresponding period of last year, showing an increase of £161. The total receipts to date, from January 1st, 1892, are £7,954, against £6,965, an increase of £989.

COMMERCIAL CABLE COMPANY.—This Company announces the payment on April 1st of the quarterly dividend at the rate of 7 per cent. per annum.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).— The receipts of this Company for the month of February amounted to £1,865, as compared with £1,953 in the corresponding period of last year, a decrease of £88.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment on the 14th April next of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum on the Preference shares of the Company for the quarter ending March 31st; and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income tax, in respect of profits for the quarter ended December 31st last. The register of transfers will be closed from the 7th to 14th April, both days inclusive.

"ESTON" ARC LAMP SYNDICATE (LIMITED).—The prospectus is issued of this Syndicate, which is formed with a capital of £25,000, divided into 5,000 shares of £5 each; payable, £1 on application, £2 on allotment, and the balance at not less than one month's notice. The first issue is for 2,200 shares at par. Amongst the Directors is Mr. George North, A.I.E.E.; the consulting engineer is Mr. James Swinburne; the secretary is Mr. T. H. Robinson; and the offices (*pro tem.*) are situated at 26, Thavies'-inn, Holborn, E.C. The Syndicate is formed to acquire the patent rights for England and the chief cities of the Continent, Canada, and the United States in the "Eston" arc lamp, for which thorough efficiency is claimed and on behalf of which a very satisfactory report is made by Mr. C. E. Spagnoletti, who concludes his report by saying, "I consider it one of the best and cheapest arc lamps in the market." The price paid for patents is £15,000, payable as to £6,000 in cash, and £9,000 in shares, this sum to include all expenses for the registering and floating of the Syndicate. Bankers: The City Bank, Holborn-viaduct, E.C.

GREAT NORTHERN TELEGRAPH COMPANY (LIMITED).—The traffic returns of this Company in February, 1892, were £20,800; 1st January to 29th February, 1892, £40,800; corresponding month, 1891, £41,600; 1890, £39,400.

HOBART TRAMWAY COMPANY (LIMITED).—The prospectus of this Company was issued early this week. The authorised share capital is £105,000 in £1 shares, of which the current issue is for 60,000 shares, 45,000 shares being held in reserve for the debenture holders. The trustees for the debenture holders are the London and Australasian Debenture Corporation (Limited); the consulting engineer is Sir Benjamin Baker, K.C.M.G.; the contractors for electric plant are Messrs. Siemens, Brothers and Co. (Limited); the secretary is Mr. G. Carnaby Harrower, C.A.; and the offices of the Company are at College Hill-chambers, Cannon-street, London, E.C. The object of the Company is to acquire the Hobart Tramways and to equip the same by electric power. Various calculations are made, with the result that a possible revenue of £25,555 is produced The

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tramway will be worked by overhead conductors, and the necessary work, are the Directors believe, within the powers conferred by the Act of Parliament regulating the district. Messrs. Siemens Brothers and Co. have contracted to equip the line with 20 cars, and the electrical fittings and accessories, for the sum of £33,000, and to complete the line by December 31, 1892; and they have also agreed to work the line for twelvemonths at 4d. per car mile. It is intended to apply to the local authorities of Hobart for powers to light by electricity the streets, &c., and to supply power for general purposes. We must refer our readers to the prospectus for further details. The list opened on Monday, and closed on Wednesday last.

ORIENTAL TELEPHONE COMPANY (LIMITED).—The Directors of this Company have resolved, subject to audit, to recommend to the shareholders a dividend at the rate of 2½ per cent. on the entire paid up capital of the Company, which dividend being only payable to the holders of ordinary shares, is equivalent to £3. 12s. 2d. per cent. on each share of 11s. paid. This is the same dividend as was paid last year.

PIONEER TELEPHONE COMPANY (LIMITED).—The Press are informed that letters of allotment in this Company have been posted.

WESTERN UNION TELEGRAPH COMPANY.—This Company has declared the usual quarterly dividend of 1½ per cent.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the month of February amounted to £2,685, as compared with £2,563 in the corresponding period of last year, an increase of £122.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, March 2.	Price Wednesday, March 9.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending March 9. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,98[illegible]	Stock	16/0	Anglo-American	49 50	49 50	5 5 0	Jan., Apr., July, Oct	49	..
£2,849,51[illegible]	Stock	32/0	Do. Preferred	88 89	88 89	5 18 0	" "	89	88½
£2,849,51[illegible]	Stock	5/0	Do. Deferred	11¾ 12¼	11¼ 12	..	" "	11⅞	11⅝
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10¾ 11¼	10¾ 11¼	7 2 3	Mar., June, Oct., Dec.	11⅛	10[illegible]
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	104 108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	152 157	155 160	4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	11	10½
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	16¾	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½ 3¾	3½ 3¾	6 18 8	April and October..	3⅛	..
6,000	5	10%	Do. Preference 10%	8½ 9½	8½ 9½	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11 11¼	11 11¼	6 5 0	Jan., Apr., July, Oct.	11[illegible]	11[illegible]
400,000	10	2/6	Eastern	14⅜ 14½	14⅜ 14½	4 7 5	" "	14⅝	14½
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15½	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107 110	108 111	3 12 1	May and November	109¾	108½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	105 108	106 109	4 11 9	February & August	108	107½
250,000	10	2/6	Eastern Extension	14⅞ 15⅛	14⅞ 15⅛	4 12 7	Jan., Apr., July, Oct	15⅛	14⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	106 109	106 109	3 18 5	February & August	107½	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July ..	103	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	101 104	101 104	4 16 2	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99 102	99 102	3 18 5	February & August	101½	..
180,227	10	1/6	Globe Telegraph and Trust	9⅞ 10⅛	9⅞ 10⅛	5 6 2	Jan., Apr., July, Oct.	10[illegible]	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅝ 15⅛	14⅝ 15⅛	3 19 10	" "	14⅝	..
160,000	10	5/0	Great Northern	18¾ 19¼	18¾ 19¼	4 8 4	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41 43	41 43	5 16 3	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	108 106	105 108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	7⅛ 8	7⅛ 8	5 3 2	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6%	116 121	117 122	4 18 4	" "	117¾	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	100¼	..
30,000	10	2/0	West Coast of America	4 5	4 5	..	January and July ..	4½	..
£150,000	100	8%	Do. Debentures 8% 1902	102 106	102 106	7 10 11	June and December	104½	104
88,321	10	1/0	West India and Panama	1½ 1⅝	1⅝ 1⅞	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 10⅛	9½ 10⅛	5 17 1	May and November	10⅛	10
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8½ 9⅛	8½ 9⅛	6 6 4	" "	..	..
67,007	15	6/0	Western and Brazilian	10 10⅛	10 10⅛	7 2 10	" "	10⅜	10¼
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 7	" "	6⅝	6½
30,364	7½	7/6	Do. 5 per Cent. Deferred	3⅞ 4⅛	3⅞ 4⅛	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	101 104	102 105	5 14 3	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	101 104	102 105	5 14 3	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£1 8,100	£100	6%	Do, 6 per Cent. Sterling Bonds	97 100	97 100	6 0 0	March & September	..	..
			TELEPHONES.						
£24,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜ ½	⅜ ½	8 7 7	May and November	..	..
£20,000	£1	4·76d.	Oriental (11s. paid)	¼ ⅜	¼ ⅜	6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅛ 4⅜	4⅛ 4⅜	6 17 2	June and December	4[illegible]	4[illegible]
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13 13½	12½ 13½	4 8 11	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	11⅛ 12⅛	11⅛ 12⅛	4 16 0	" "	..	..
420,000	£10 0	4¼%	Do. Deb. Stk. 4¼% Prov. Cert. (fully pd.)	104 107	104 107	4 4 1	January and July ..	106¼	105
58,000	5	1/0	United River Plate	1 2	1¼ 2⅛	..	" "	..	..
£146,870	Stock	5%	Do. 5 per Cent. Debenture Stock	80 90	80 90	5 11 1	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£6 paid)	8 8½	8 8½	..	—	8[illegible]	8¼
19,200	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
8,332	£5	..	House to House Electric	4½ 5	4½ 5	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5½ 6	5½ 6½	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½ 6	5½ 6½	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 paid)	2½ 2⅞	2½ 2⅞	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	4½ 5	4½ 5	..	March	..	..
111,000	5	..	London Electric Supply	¾ 1⅛	¾ 1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8½ 9	8½ 9	..	..	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½ 5½	4½ 5½	..	..	8⅛	8⅜
18,680	£5	5/0	St. James' and Pall Mall	8½ 8⅞	8½ 8⅞	..	..	..	..
7,900	£5	7%	Do. 7% Preference	7½ 7⅞	7½ 7⅞	..	..	8⅛	..
42,853	5	..	Westminster Electric Supply (fully paid)	6 6½	6½ 6¾	..	..	7⅛	7½
								6[illegible]	6⅝
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/0	Brush Electrical Engineering	3⅛ 3⅝	3⅛ 3⅝	..	..	3[illegible]	3[illegible]
69,996	2	6%	Do. 6 per Cent. Preference	2 2¼	2 2¼	5 7 7	..	2[illegible]	2[illegible]
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 6	5½ 6	5 16 8	January and July ..	5⅛	5[illegible]
17,139	5	17%	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	5⅞ 6¼	5⅞ 6¼	..	—	6¼	5⅞
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅝ 3⅛	3 3⅛	..	—	3⅛	2⅝
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & Telegraph Works	21 22	19½ 20½	4 17 7	February & August	20½	19½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 106	4 4 11	March & September	..	..
11,314	£10	6/1	International Okonite Limited Ordinary	3½ 4½	3½ 4½	..	..	..	..
11,314	£10	8/0	Do. Preference	8 9	8 9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	1[illegible] 1[illegible]	½ ½	..	..	..	..
78,949		F/7½	Swan United (£3. 10s. paid)	4 4½	4 4½	8 11 10	May and November	4⅜	4[illegible]
86,250	12	12/0	Telegraph Construction and Maintenance	45 47	44 46	5 4 2	March and July.....	46½	45
150,000	100	6%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July .	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½ 1	½ 1	6 0 0	..	..	—
—	£5	8%	Do. Preference (fully paid)	2½ 2¾	2½ 2½	11 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	—	—	..	..
50,000	£10	..	City and South London Railway	2½ 3½	2½ 3½	..	..	..	..

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NOTES.

Misfortunes never come singly; and, if there are any misfortunes about, the London Electric Supply Corporation is sure to come in for its share. At about two o'clock on Thursday afternoon last week a fire broke out in a store of cotton waste, oils and refuse, under one of the arches of the South-Eastern Railway near Spa-road. The four Ferranti mains from Deptford run along the parapet just over the arch, one above the other. The upper one was alone in use at the time. The first warning was a blink in the lights. A few minutes afterwards the voltmeter at the office of the Company at Adelphi-terrace went up to 110, and almost immediately afterwards the lights went out. On telephoning to Deptford to inquire for the cause, it was understood that the first main had gone; the load was shifted to another, and in a few moments the same events were repeated, and the officers of the Company learned that the whole of their communication with Deptford was interrupted. At Deptford considerable sparking occurred on the dynamos, and continued until the fuses went. The injury to the machines was not serious, and has been repaired.

One of the employés happened to pass the scene of the fire on his way to Deptford, and finding that the generators had been shut down, suggested the fire as the cause of the breakdown. A gang was immediately sent off, and succeeded in establishing a temporary communication by 11 o'clock in the evening, and new lengths of Ferranti mains were laid in the course of Friday. The London Electric Supply Corporation warned as many of their customers as they could in the course of Thursday afternoon that the light could not be supplied that evening, but very considerable inconvenience was naturally felt. The misfortune was of so purely an accidental character that no blame could possibly be attached either to the Company or the system which it employs. Storage batteries and continuous current would not have mitigated the effect; while if electric lighting as a whole be blamed, it must be remembered that had gas mains, instead of Ferranti mains, been attacked by the fire, the disaster would have been enormous.

The Ferranti mains have been rigorously tested to ascertain what temperature they will withstand, and on first hearing of this fire, it might have been thought that nothing short of a collapse of the archway would have injured them. We learn, however, that the flames were so intense that the outer iron tube was burned away, as well as the outer copper conductor, and that long lengths of the main were split, curled, and twisted. The insulation between the inner and outer conductors blazed violently, until a short circuit occurred. The London Electric Supply Corporation were not the only sufferers; the flames also destroyed the London and Paris telephone wires on the opposite side of the road which runs along side the arches and interrupted the railway traffic.

The experiments which are arranged by Messrs. Siemens Bros. as a sixpenny side-show at the Crystal Palace are well worth seeing, even by those who were present at the lectures of Mr. Nikola Tesla and Messrs. Bourne. Among the experiments, which are repetitions of those of Mr. Tesla, is that of the two concentric rings of wire. The radial discharge is comparatively feeble; but attention has been drawn to a number of small brilliant points on the wires, and it has been suggested that these are nodes of longitudinal vibrations. On the occasion on which we witnessed this experiment, the rings were roughly made of wire; but the disposition of the bright points, if really due to nodes, should have been spaced at perfectly regular, though perhaps not equal distances. This was not the case, and the irregularities were certainly due to something more than the crookedness of the wire, both in the outer and the inner ring.

The experiment of Dr. Oliver Lodge at the Physical Society, to which we alluded when commenting on Mr. Tesla's experiments, consisted of a pair of ordinary Leyden jars and a circuit of bare copper wire,, about 60ft. long. This acted as a stopped organ pipe, the remote end, which was insulated, being a node at which the variation of pressure was the greatest. Dr. Lodge described experiments with much longer wires, in which complete waves of the higher harmonics were visible. There was a gradual increase and a gradual decrease of brilliancy along the wire, exactly like the varying amplitude of vibration of a stretched string; but the spark-like points of light on Messrs. Siemens' wire were set at about five or six to the inch, if we remember rightly. The smallest wave length that Dr. Lodge has been able to produce has been about six centimetres, and the capacity in the circuit was only a metal ball of about six centimetres diameter. The condenser at the Crystal Palace was a large affair, composed of a roll of india-rubber sheet

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with a conductor plate coiled up in it. We see no reason to suppose that these points of light were due to high harmonics, and are inclined to think that if quarter-inch waves are to be produced, the whole condenser and circuit would have to be small enough to go easily in a waistcoat pocket.

It is as well that the battle royal which has recently taken place within the Institute of Chemistry should be brought to the notice of electrical engineers. As is so frequently the case, the members of the Institute had drifted into the vicious habit of submissively voting year after year for official nominees, with the inevitable result that they woke up one fine day to find that the Council no longer accurately represented its electors.

So far as we can gather, the main cause of the disturbance was the alleged undue proportion of professors on the Council, and the consequent exaltation of technical training. Pupilage, pure and simple, was in danger. Hence these tears! The opposition to the "techniker" does not originate here more than elsewhere solely from a dislike of that young gentleman's admitted defects; and those who wish to live in peace and charity with the veterans of chemistry must take Bacon's advice to heart, and innovate "by degrees scarce to be perceived."

The attack, although a failure so far as the election of Council was concerned, will have the effect of reminding the leading lights of the Institute of Chemistry that there are two sides to every question, a result in itself of no little value. May we take the election of a member of the Institution of Electrical Engineers to the important post of registrar and secretary as an indication of a new movement to bring the Institute into closer contact, not only with its own members, but with the members of the many professions to which Chemistry is, or should be, allied? It is a commonplace to say that chemists and electrical engineers can afford each other considerable assistance; but do they? Take, for example, the breaking-down of insulators by the prolonged application of high-alternating potentials; neither the freaks of dielectrics nor the vagaries of secondary batteries can be explained on purely mechanical grounds. Minute chemical changes, which escape the eye of an electrical engineer with a dash of the chemist in his composition, might well be detected by a skilled chemist. Why not appoint a joint Committee of Investigation?

The meeting held at the Mansion House on Friday last to consider the Chicago Exhibition, although largely attended, was of a somewhat disappointing character. The voice of the manufacturer was not heard in the land, but in place thereof we were treated to a series of mingled appeals to patriotism and pocket. *Facile princeps* should indeed be our motto everywhere, and especially in the United States of America. But to express an admirable sentiment is one thing, to pay for it oneself is quite another. If exhibiting at Chicago is a mere matter of patriotism, the cost of the patriotic display should not fall entirely upon one section of the community; the Government grant should have been such as to permit of the tax upon exhibitors being reduced to a minimum, if not entirely done away with. On the other hand, if it is as the speakers on Friday almost without exception asserted, of vital importance to Great Britain's commercial supremacy that she should be adequately represented at Chicago, then what are we to think of those who accepted the onerous and thankless duties of Royal Commissioners with but £25,000 at their back? If the commercial supremacy of the World is in reality the guerdon, £25,000, plus the enlightened self-interest of a few individual firms, are surely not equal to the gravity of the occasion.

Great stress was laid upon the understanding—not promise, be it noted—that foreign exhibitors would be allowed to label their wares with placards setting forth in bold type their selling prices with and without the McKinley Tariff. To allow the World's Fair Columbian Exposition to be converted into a hostile demonstration against Protection would be an unparalleled act of magnanimity on the part of the American nation and a strange piece of political folly on the part of the Republicans. Before foreigners exhibit on the strength of this "understanding," an Act of Congress would seem desirable. *Timemus Americanos et dona ferentes.*

The office and duties of scrutineer at the meetings of the Institution of Electrical Engineers are not arduous, as the President has observed on several occasions; but there is a general desire to avoid catching his eye when the appointment has to be made, especially when, as on Thursday, last week, experiments were about to be performed. We venture to suggest that the selection be made from among those members whose subscriptions are in arrear.

Erfurt.—The Gas Company at Erfurt is about to undertake the supply of electricity.

Cannstadt.—It is proposed to light this town by electricity. Power would probably be derived from the River Neckar.

Tuttlingen.—The Town Council of Tuttlingen has the intention of adopting the electric light. Water-power to the amount of 500 H.P. is available.

Electric Light Cables.—The first line of the second paragraph of Mr. Connolly's letter last week should read "The separator should consist of a non-vulcanised rubber compound."

Electric Traction in Wurtemburg.—The first electric railway in Wurtemburg, between the Baienfurt paper mills and the station at Ravensburg, a distance of over two miles, has just been opened.

Halle.—The gross receipts of the tramway at Halle for last year (during the latter part of which electricity was adopted) amounted to about £9,600, being £2,350 in excess of those for the previous year.

Electricity Applied to Mining.—A Paper on "Electricity Applied to Mining," by Mr. Llewelyn B. Atkinson, was read at the last meeting of the South Staffordshire and East Worcestershire Institute of Mining Engineers.

Cooking by Electricity.—Experiments in cooking by electricity were made in Wallace's Restaurant, Neville-street, Newcastle, last week, under the auspices of the Newcastle and District Electric Light Company.

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Royal Society.—The following Papers were down for reading yesterday before the Royal Society:—Dr. Hopkinson, F.R.S, and E. Wilson, "Dynamo-Electric Machinery;" Mr. R. T. Glazebrook, F.R.S., and Mr. S. Skinner, "On the Clark Cell as a Standard of Electromotive Force."

Glasgow.—At a Dean of Guild Court held on Thursday last week plans were submitted by the Lord Provost, magistrates, and Town Council of Glasgow of buildings which they propose to erect at the corner of Wellington-street and Mains-street. The plans, which were those of the Corporation's new electric lighting station, were passed.

The C.S.P. System of Concentric Wiring.—In the description on p. 489 of our last issue of a new and ingenious system of concentric wiring we omitted to mention that Mr. David Cook, General Manager to the City of London Electric Lighting Company, was a joint inventor of it, together with Mr. Carrington Smythe and Mr. Ernest Payne.

The Cost of Lighting the House of Commons.—For the coming financial year the electric light bill of the House of Commons is estimated at £1,800; the gas bill at £3,200; while the bill for oil lamps will not exceed £1,550—a total of £6,550. Taking the Board of Trade unit at 7d., an £1,800 bill would mean that no less than 61,000 units are likely to be consumed.

Institution of Electrical Engineers.—A students' meeting was held at the library of the Institution on Friday, the 11th, Prof. George Forbes, F.R.S., presiding. Messrs. Drysdale and Poore read a Paper on "Electric Welding," which was illustrated by photographs projected on to a screen, as well as by specimens of welds made by this process. On the 25th inst. Mr. C. A. Gawthorp will read a paper on "Measurements of Power in Alternate Current Circuits."

Lectures.—The Saturday Art and Science Lecture at the South Kensington Museum was delivered by Mr. C. V. Boys, on "Electric Spark Photography as applied to flying Bullets and other rapidly moving Bodies."——A lecture to the Insurance Institute of Manchester on "The Fire Risks of Electric Lighting" was given on Thursday evening last week at the Electrical Engineering Branch of the Manchester Technical School by Mr. Haldane Gee, chief lecturer in electrical engineering.

Institute of Chemistry.—At the annual general meeting of the Institute of Chemistry, held recently, the officers elected were as follows:—President, Dr. W. A. Tilden, F.R.S. Vice-Presidents: Dr. James Bell, C.B, F.R.S.; Mr. M. Carteighe, F.C.S.; Dr. E. Frankland, F.R.S.; Mr. Charles E. Groves, F.R.S.; Dr. W. Ramsay, F.R.S.; Dr. J. Emerson Reynolds, F.R.S. Treasurer: Mr. David Howard, F.C.S. Mr. G. H. Robertson, F.C.S., A.I.C., A.I.E.E., was appointed Secretary and Registrar, in succession to Mr. Charles E. Groves, F.R.S.

Festiniog Local Board.—At the last meeting of this Board the Gas Committee suggested either an expenditure of a large amount to put the present gasworks in proper working order, or that the works should be done away with and electricity substituted. After some discussion it was ultimately agreed that the Bangor Gasworks manager should be asked to examine and report on the gasworks, and give his estimate; and also that an electrical engineer should be asked to report on the electric lighting of the district, both reports and estimates to be considered at the next meeting.

Taunton.—The Special Committee of the Town Council appointed to consider the proposed purchase of the Electric Light Works have reported as follows:—"Your Committee report that they have prepared a report on the subject of the Electric Lighting Company's undertaking, which they have ordered to be printed, and three copies to be sent to each of the members of the Town Council; also a copy to each of the local papers. The Committee recommend that a special meeting of the Council be held on Tuesday, March 22nd, at half-past ten in the forenoon, to consider the report."

Worcester.—At the last fortnightly meeting of the Watch Committee, the Town Clerk presented the report of Mr. Preece, who had been consulted by the Committee for the consideration of the electric light tenders. Mr. Preece estimated the annual revenue to be derived from the proposed plant when it was fully taken up, if 6d. per Board of Trade unit be charged, at £10,800, and the total working expenses £5,500, showing a profit of £5,400. The estimated cost of building at the weir was £6,900, but the reduction in the cost of working expenses through the use of water-power fully justified this. He estimated that they would require £40,000 for their undertaking. The Committee decided to recommend that the Brush Company's tender be accepted.

The Electric Transmission of Power at the Thomson-Houston Company's Works. The Thomson-Houston Company's works at Lynn, Massachusetts, having of late years increased so greatly, and the consumption of coal in the works and difficulties of transport having become so great, it has been decided to establish a generating station on the river banks, and to transmit the energy to the works by electricity. For that purpose the Company have bought a plot of land on the River Sangus, and the generating station will be placed at a spot where the vessels can discharge the coal directly. In this way not only will economy of transport be realised and successive transhipments of the coal avoided, but it will also permit of buildings which had become too small being enlarged.

Driving Looms by Electricity.—The City Council of St, Etienne has decided to apply electric power to all the hand-looms in the city, and contracts have been made with an electric company for the necessary plant. The dynamos are to be driven by water from the city reservoirs. There is practically an unlimited supply of water, with a fall of upwards of 100ft. The bulk of the enormous output of ribbons (£4,500,000 a year) is the product of house industry. The weavers for the most part own their own looms, and operate them by hand in their own houses. There are 18,000 looms which are thus distributed among the homes of the weavers, while the number of looms driven by steam in the few ribbon factories of the town is only 5,000. The 18,000 looms of the independent weavers are valued in the aggregate at £900,000.

The Association for the Improvement of Geometrical Teaching.—An important memorial will shortly be brought before the Board of the Faculty of Natural Science, Oxford, by the Council of the Association for the Improvement of Geometrical Teaching. It relates to what the Council regard as a serious defect in the Oxford Pass Examination Papers in geometry. These generally consist entirely of propositions enunciated without any variation from the ordinary text of Euclid, and scarcely any attempt is made to discover whether a student's answers are other than the outcome of a mere effort of memory. The Council are of opinion that such Papers have the effect of a direct incentive to unintelligent teaching, and respectfully ask for the introduction of simple exercises and of simple questions on the book-work set in order to promote the rational study of geometry.

London County Council and Electric Light Mains.—At the meeting of the London County Council on Tuesday, 1st inst., conditional sanction was given to some works of the Notting Hill Electric Lighting Company, and of the House to House Electric Light Supply Company. The St. James and Pall Mall Electric Lighting Company gave notice of intention to lay mains in Coventry-street, Rupert-street, and the west side of Wardour-street. They propose to lay insulated cables in pipes or bitumen conduits, or, where there is found sufficient room, to lay bare copper in Crompton conduits. Conditional sanction was given to the work. Notice was also given by the Electric Installation and Maintenance Company of intention to lay mains for the Crystal Palace District Electric Supply Company. The proposed works were considered objectionable in many respects, and the Council formally disapproved of them.

The Moebius Process.—Mr. B. Moebius, the well-known electro-metallurgist of this city, says the *Engineering and Mining Journal* of New York, has gone to Germany, where he will build an electrolytic parting plant for the *Deutscher Gold und Silber Scheide Anstalt*, at Frankfort-am-Main, the largest concern of its kind on the Continent. We are informed that an officer of this Company was sent over to the United States recently to inspect the working of the Moebius electrolytic parting process at the

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works of the Pennsylvania Lead Company, at Mansfield, near Pittsburg, Pa., and the St. Louis Smelting and Refining Company, at St. Louis, Mo. His report was so strongly in favour of the introduction of this process in Germany that it was decided to instal it at the works of the *Deutscher Gold und Silver Scheide Anstalt*, in place of the sulphuric acid process heretofore used there. The plant contracted for will have a capacity of treating 30,000oz. of Doré bullion per day.

A Mountain Electric Railway.—An interesting little electric rack-railway, on the Abt system, will shortly be opened in the Haute Savoie. The line starts from Etrembières, on the Bellegarde and Annecy Railway, and runs in a circular sweep through Monnetier to Veyrier, a branch being run up the Grande Salève (2,300ft.). The gradients range from 16 per cent. to 35 per cent.; with curves ranging from 165ft. to 115ft. radius. The line comprises two short tunnels and a number of small iron bridges. Power is obtained from the Arve, which can supply a minimum of 36 cubic feet per second at a head of 10ft., say, 600 H.P. The generating plant comprises three 165 unit (275 amperes × 600 volts) Thury dynamos, coupled to turbines with vertical axes. The rolling stock consists of 12 40-passenger cars, each weighing 12 tons. The motors are four-pole, each car being provided with two 33 H.P. motors and two sets of gearing. Each car has eight brakes, viz, four friction, two electric, and two absolute. The electric brakes are formed by the motors themselves when the car runs downhill. Along the track inverted Vignole rails, supported on iron posts and brackets, form the electric conductor. A 15 per cent. loss on the line is allowed for.

Sheffield Telephone Exchange and Electric Light Company.—Negotiations have been commenced for the acquisition of the telephone business of the Sheffield Telephone Exchange and Electric Light Company by the National Telephone Company. The local company was established in 1879, and the National Company has for some years been anxious to acquire a monopoly of the telephone business in Sheffield. The competition on the part of the National Company has been extremely keen, that Company going so far as to accept subscribers at £5 per annum in any part of Sheffield. Notwithstanding this the local company has successfully held its ground and maintained its rates, which are considerably higher than those of the National Company in Sheffield, but lower than those of the National Company in other towns. Wiser counsels appear to have at length prevailed, and the National Company has now made such fair proposals to the local company that may honourably be accepted. Should these proposals be finally approved, the local company will turn its attention to the fuller development of its electric lighting business, which for some years has been steadily increasing, and more especially in view of the fact that Parliamentary powers for the lighting of Sheffield will be granted to the Company during the present Session of Parliament.

Magnetic Disturbances.—It appears that the magnetic disturbances of February 13th and 14th affected the instruments at the Pawlowsk Observatory at the same time as elsewhere in Europe, but in the reverse manner, the declination and horizontal component being markedly and suddenly diminished, while the vertical component was slightly increased. In a note in the *Comptes Rendus* of March 7th, M. Moureaux, of the Parc Saint Maur Observatory, states that an aurora borealis accompanied by magnetic disturbances occurred on the night of March 6th and 7th. The curves for March 5th were extremely regular, but during the early part of the 6th deviations from the normal were observed. At 5 p.m. the intensity of the disturbance increased. At 9:10 p.m. all the magnetic elements underwent a sudden change. About half-past six a faint aurora was observed. At 9:10 p.m. "a luminous dark red ray of light suddenly appeared at the magnetic North, developed into a fan very rapidly, and crossed the sky from North to South, passing the zenith; the phenomenon only lasted a few minutes." The great sun spot observed at the time of the disturbance of February 13th, says M. Moureaux, disappeared on February 20th, and after half a revolution of the sun again showed itself on March 4th in a much reduced condition. On March 5th, 6th, and 7th, a number of small spots were noticed around the main one, in the midst of a vast region of faculæ.

Crystal Palace Electrical Exhibition.—The following juries were appointed for the different Sections, at a meeting held on Saturday last:—(1) Apparatus to illustrate the Phenomena and Laws of Electricity and Magnetism; Electric Telegraphs and Electric Signals; the Telephone and its Appliances:—Sir H. Mance, W. H. Preece, C. E. Spagnoletti. (2) Apparatus for Electrical Measurements; Electric Batteries (Primary and Secondary):—Shelford Bidwell, Dr. J. H. Gladstone, Charles Hall. (3) Machines and Appliances for Producing Electrical Currents by Mechanical Power; Dynamical Electricity (Electric Motors):—Prof. S. P. Thompson, W. B. Esson, Ll. B. Atkinson. (4) Commercial Transmission and Regulation of the Electric Current; Application of Electric Motors:—J. H. Greathead, A. Reckenzaun, Conrad Cooke. (5) Lighting by Electricity; Heating by Electricity; Electric Welding, Stamping, Tempering, Brazing, &c.:—General Festing, W. H. Massey, Charles Hall. (6) Electro Metallurgy and Electro-Chemistry, Electricity in Surgery and Therapeutics:—J. Swinburne, Captain Sankey, J. W. Wilson. (7) Applications of Electricity in various ways not before specified. History and Statistics of Electrical Invention; Progress and Development in Electrical Science and Construction:—Prof. J. Perry. (8) Prime Motors:—Prof. H. Robinson, Sir Douglas Galton, Prof. Unwin, J. Tomlinson, W. H. Massey. Mr. A. P. Trotter was originally nominated for Section 3. He accepted on the condition that no attempt should be made to award medals for the exhibits in that class. He was willing to assist in drawing up a report. It appeared at the meeting that the whole body of jurors agreed in the uselessness of awarding medals, but that the Crystal Palace Company were pledged to give them. Mr. Trotter declined to withdraw his condition, and made a strong protest against the principle of awarding medals for such exhibits. Mr. Ll. B. Atkinson was nominated in the place thus rendered vacant. In addition to the above the following names are contained in a list sent us by the Crystal Palace Company:—Profs. W. Grylls Adams, W. E. Ayrton, George Forbes, D. E. Hughes, and Major-General Webber.

Accumulator Traction in Paris.—At a meeting of the Société Internationale des Électriciens, on March 2nd, M. Frank Géraldy gave some particulars with regard to the accumulator cars running on the Madeleine Saint-Denis (5¼ miles), and Rue Taitbout Saint-Denis (5½ miles), lines of the Société des Tramways du Nord. The loaded cars weigh 12 tons, each being fitted with two 13 H.P. 200-volt Manchester motors, running at 1,200 revolutions. Double reduction gear is employed. Each pair of wheels is mounted on a square frame, connected to the car by a pole-bolt, and supporting the body of the car on four rollers placed at the four corners. An arrangement of springs enables the frame to adapt itself to the sharpest curves. The accumulators are supplied by the Société pour le Travail Electrique des Métaux. Each car has a battery of 108 cells, each cell containing 37½lbs. of active material with 12 plates 8 inches square and ¼ inch thick. The containing vessels are of ebonite, with india-rubber lids. The batteries weigh two tons, and can supply 50 H.P. hours, which is sufficient for a run of over 40 miles. By means of three levers the driver can reverse the motors, place them in series or in parallel, or cut one out of circuit altogether, a hand-wheel enabling him to alter the grouping of the cells. Interlocking devices preclude wrong manipulations. The following table of data is of interest:—

—	Out.			Home.		
	In Paris.	Outside Paris.	Complete journey.	Outside Paris.	In Paris.	Complete journey.
Maximum tractive effort, in lbs.	952·6	620·4	...	713	730·4	...
Maximum tractive effort, lbs. per ton	79·2	51·7	...	59·4	61	...
Maximum H.P.	12·6	16·71	...	19·2	14·6	...
Average tractive effort, in lbs.	277·2	102·5	183·5	182·6	223·5	201
Average tractive effort, lbs. per ton	23·1	8·6	15·3	15·3	18·7	16·7
Average H.P.	5·24	2·75	4·1	4·92	4·51	4·71
Speed (miles per hour)	6·82	9·92	8·25	9·92	7·44	8·62

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GRATE AREA.*

This depends upon the amount of fuel to be burnt per hour, and is inversely as the rate of combustion per square foot, or if

G = grate area,

C = lbs. fuel to be burnt per hour,

r = rate of combustion in lbs. of fuel per sq. ft. of grate per hour, $G = C/r$,

r, with chimney draught, varies from 5lb. to 30lb. of coal,

r, with forced draught, may be from 30lb. to 120lb. of coal.

Unless the exact conditions of working the boiler be known it is well to make the grate area ample, and to reduce it by placing fire bricks on the bars, to suit the working conditions. The best results depend greatly upon the proper rate of combustion for the available draught and kind of fuel. Mr. L. E. Fletcher, in his report to the Manchester Steam Users' Association on the Wigan coal trials in 1868, says that:—

"At the commencement of the trials only 8·01lb. water were evaporated per lb. of coal, and 35·88 cubic feet of water per hour with a consumption of 20lb. of coal per hour per sq. ft. of grate; subsequently, however, the results were considerably improved, and 11·11lb. of water were evaporated by one of coal, with a speed of 46·19 cubic feet of water per hour, and 25lb. of coal per hour per sq. ft. of grate. This improvement was obtained simply by slight modifications in the proportions of the furnaces and treatment of the fires, 115 preliminary experiments were made, during which it was found of advantage to *reduce the length of the fire grate* from 4ft. to 3ft., to *adopt a blind dead plate* instead of a perforated one, and to slightly *lower the level of the fire grate* so as to increase the height of the flame chamber. No bar was found to give a better result than a wrought-iron one an inch thick, with a half-inch space as windage. The perforations for the admission of air through the fire door were also reduced from 3·2 sq. in. per sq. ft. of grate to 1·6 sq. in., while with the thickest fires the doors were left 1in. or 1½in. ajar for a minute or so after firing to prevent the formation of smoke. Both *spreading* and *coking* fires were tried, the latter giving more economical results and producing less smoke, while in addition a higher result was obtained by thickening the fire from 6in. to 9in, and again from 9in. to 12in."

Of course, it is not best to use a thick fire in all cases, though the thicker the fire the less probability there is of cold air getting through the fire. With forced draught the fire may be 18in. to 36in. thick, the length of the grate should not exceed 7ft., in fact, 6ft. is almost as long as it is desirable, and if the grate exceed 5ft. a good fireman is necessary. The breadth may be from 15in. to 4ft., the most convenient breadth being about 18in. to 30in. Long grates should slope down from the fire door about 1 in 6.

For bituminous coal a low crown, as in the flues of a Lancashire boiler, is most suitable; while for anthracite or coke, a more open fire, as in the Babcock and Wilcox boiler, is best. To obviate smoke it is sometimes advantageous to admit air at the bridge or directly over the fire, or it may be blown in by steam jets. Water in the ashpit assists in preventing the formation of clinkers.

Rankine gives the following rate of combustion in lbs. per hour, per sq. ft. of grate:—

I.—*With Chimney Draught.*	lbs. per sq. ft. per hour.
1. The slowest rate of combustion in Cornish boilers	4
2. Ordinary rate of these boilers	10
3. Ordinary rates in factory boilers	12 to 16
4. Ordinary rates in marine boilers	16 „ 24
5. Quickest rates of complete combustion of dry coal, the supply of air coming through the grate only	20 „ 23
6. Quickest rate of complete combustion of caking coal, with air-holes above the fuel to the extent of ⅓ area of grate	24 „ 27
II.—*With Draught. (Blast Pipe or Fan.)*	
7. Locomotives	40 „ 120

Ratio of Grate Area to Heating Surface.

Type of Boiler.	Heat surf. ÷ Grate area.
Cylindrical, with internal flue	20 to 25
Multitubular marine	25 „ 30
„ loco. chimney draught	25 „ 35
„ loco. forced draught	35 „ 90
Vertical	10 „ 25
Water tube	20 „ 55

Formula for finding the Amount of Water which would be evaporated under Different Conditions for the same Amount of Fuel.

Let w = weight of water per lb. fuel to be found.

t = temp. Fahr. of feed water decided upon.

H = total heat of steam at pressure decided upon.

w_1, t_1, H_1 = respective values for the above as given at the trial.

then
$$w = w_1 \frac{H_1 + 32 - t_1}{H + 32 - t},$$

and if w_{212} = the weight of water evaporated per lb. from and at 212° F.,
$$w_{212} = w_1 + \frac{H_1 + 32 - t_1}{966}.$$

The following remarks have reference to the results of some evaporative tests of Lancaster and Galloway boilers carried out at Wigan, by Mr. L. E. Fletcher:—

Averages without Economiser.

	Lbs. water from 100° per hour	Lbs. water per sq. ft. heating surf. per hour.	Lbs. water per lb. fuel from and at 212°
Lancashire	4960	6·5	10·31
Galloway	4920	6·8	10·34
With Economiser.			
Lancashire	5650	7·4	11·56
Galloway	5380	7·5	11·82
With Draught shut off External Flues.			
Without Economiser.			
Lancashire flues	5170	11·2	8·23
Galloway flues	6000	11·6	8·50
With Economiser.			
Lancashire flues	6160	13·2	10·08
Galloway flues	5550	12·8	10·16

The Galloway boiler was 2ft. shorter and 6in. less in diameter than the Lancashire boiler. The Lancashire flues, having 8 per cent. more heating surface, evaporated more water with rather less efficiency than the Galloway flues. The rapidity or total evaporation was greater without the external flues, but the efficiency was less. The Galloway boiler used in the above tests, although less in size, had 6 per cent. more heating surface, and therefore should require somewhat less coal for getting up steam. Inserting four Galloway tubes in each of the Lancashire flues, making 30 sq. ft. additional surface, resulted in an increase of efficiency of about 3 per cent. at the same rapidity. Two kinds of coal were used, viz., best Lancashire and slack, with different thicknesses of fire and different modes of firing.

Deductions.

A 9in. fire was better than 6in., and a 12in. fire was better than a 9in. The 4ft. grate was better than the 6ft. in evaporative efficiency by about 9 per cent. When equal quantities of coal were burnt per hour the 4ft. grate evaporated 11 per cent. more water; but when the 6ft. grate burnt 19 per cent. more coal, the rapidity of evaporation of the 4ft. grate was about 15 per cent. less. With round coal coking fires gave slightly best results. With slack coal the spreading fire evaporated 25 per cent. more than the coking fire, but with 4 per cent. less efficiency.

Admitting air above the fire gave 7 per cent. higher efficiency, but about 3 per cent. less rapidity, while the admission

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Average Results of Tests by Mr. E. L. Fletcher on Different Thicknesses of Fires at Wigan.

Character of trial.	Lbs. water at 100° per lb. coal.	Cubic feet water at 100° per hr.	Lbs. coal per sq. ft. grate.	Minutes of smoke per hour.		
				Very light.	Brown.	Black.
Coking firing fires 14 in. thick	10·35	47·22	27	2·4	0	0
„ „ „ 12 „	10·06	45·67	27	2·8	0	0
„ „ „ 9 „	9·65	44·00	27	1·0	0	0
Coking firing 12 in. thick, perforations in fire door open after charging	10·13	46·36	27	3·2	0·0	0·0
Coking ditto with perforations constantly closed	9·75	47·03	39	12·6	1·4	·6
Spreading ditto with perforations in fire door open after charging	9·81	51·37	32	20·8	5·3	4·2

The results show an evaporation varying from 5·5 to 6·5 lbs. water per hour per sq. ft. of heating surface.

of air at the bridge was about 2½ per cent. better than admission at the fire door; in these cases 2 sq. in. of air-way were allowed at the door and 1 sq. inch at the bridge. Above 2in. of air-way at the door the efficiency and rapidity both decreased, but at the bridge 3in. to 4in. could be used, without perceptibly altering the efficiency. Mr. Fletcher concludes from this that smoke must be prevented to obtain the highest efficiency, though in aiming at the highest rapidity smoke is made. Smoke was as well prevented in burning slack as in burning round coal; its efficiency was, however, about 1½lb. of water per pound fuel less than round.

Trials were made on 65 internal flue cylindrical boilers in various mills in firing slack without smoke, without loss of rapidity. The alternate side spreading system was adopted, the grates averaged about 6ft. long, and 19·25lb. coal per sq. ft. of grate.

Average results per boiler:—

Very light smoke, per hour	11·5 minutes.
Brown	2·3 „
Black	·3 „

The above table is compiled from tests made by Mr. L. E. Fletcher on a boiler of the marine multitubular type at Wigan in 1868. The boiler was of very cramped proportions, and by no means calculated to develop the highest results. It was 8ft. 6in. long by 8ft. 10in. high, 5ft. wide, and contained 124 tubes, 2¼in. diam., 5ft. long each, and two furnaces, each 1ft. 8⅝in. wide.

Heating surface of tubes	365 sq. ft.
„ „ flame chamber and furnaces, including ashpit	128 „
Total heating surface	493 „

A further test on the Wigan boiler was made with forced draught by means of a steam jet applied to the chimney, from another boiler at 30lb. pressure, when it was found that 41lb. coal were burnt per sq. ft. of grate, evaporating 69·13 cubic ft., that is, 8·71lb. of water per sq. ft. of heating surface per hour, with an efficiency slightly reduced to 10·18lb. water evaporated from 100deg. per lb. of coal.

THE BEHAVIOUR OF INSULATING MATERIALS UNDER THE ACTION OF HIGH POTENTIAL DIFFERENCES.

Mr. Spottiswoode, in March, 1882, Mr. De la Rue, in June of the same year, and Mr. Nikola Tesla, last month, have demonstrated, by brilliant experiments, the effect of high-pressure discharges from the largest induction coil, the largest primary battery, and from a dynamo of the highest frequency that has ever been known. On Friday last, the brothers H. B. and W. Fox Bourne demonstrated before the Old Students' Association the effects of a transformer, which yields a higher pressure than any previous one. It may be argued that there is not much difference between an induction coil and a Hedgehog transformer, and that Mr. Spottiswoode's coil will give a 42 in. spark. The practical difference consists in the current yielded; 100,000 volts have been exceeded by many experimenters, but 85,000 volts with 4½ H.P. behind them, that is with a current of $\frac{1}{50}$ ampere, has never been shown before a scientific society. Messrs. Siemens Bros. show experiments with 50,000 volts at the Crystal Palace, and the transformer they use is marked as being capable of giving a current of two amperes. The Hedgehog, which has been much more recently added to Messrs. Swinburne and Co.'s stand, will give 130,000 volts and $\frac{1}{3}$ ampere. The practical value of transformers yielding such enormous voltages is at present confined to experimental purposes; and it is well that experiments should be carried out with them before any attempt is made to apply them to useful purposes. The transformer used on Friday last was one with a ratio of 800 to 1, the insulation consisting of paper and oil, the whole being enclosed in an earthenware cylinder resembling a large drain-pipe.

One of the most important matters upon which all experiments with these voltages must be based is that of sparking distance; and while there are certain discrepancies between the results arrived at by Messrs. Bourne and those of Messrs. Siemens and De la Rue, there appears to be a general resemblance between them. The actual value of the sparking distance, on the other hand, is considered by Messrs. Bourne to be of small practical importance. Confidence in the results was given by experimental measurements made before the audience, and these agreed very well with the curves which were exhibited (Fig. 1). Needle points were used for the terminals, and the volts were measured with a large electrostatic voltmeter, consisting of two cylinders immersed in oil. On turning on the current the well-known violet glow of the brush discharge was seen, and as the resistance in the exciting circuit of the dynamo was diminished the air broke down, and an arc was formed. As in the Bernados electric welding process, the arcs bore a singular resemblance to long blowpipe flames. In order to show the feeble insulating powers of substances which are generally regarded as non-conductors, some very interesting experiments were carried out at pressures of sixty to seventy thousand volts. A sheet of good ebonite offered a passage to a discharge across its surface, while the distance between the terminals was many times greater than the ordinary sparking distance in air. Wires from the transformer were connected to the stalk and groove of a Johnson and Phillips' oil insulator, which had been dried and filled with clean resin oil. Brush discharges immediately occurred over the surface of the porcelain, and when 60,000 volts was reached a spark jumped from the wire to the stalk. A bar of slate, about 20in. long, 2in. wide, and 1in. thick, acted practically as a conductor, a good discharge pouring into it from the terminals; and as a further proof, two slate pencils were used to act as carbons of an arc lamp, the arc springing across a gap of some 2in., and burning quite freely. A sheet of asbestos behaved very much as did the slate. A very interesting experiment, showing the creeping discharge in a piece of dry wood, was exhibited. Copper wires were wrapped around the ends of a lath about 20in. long; small sparks, tracing charred furrows in the wood, appeared to crawl out in irregular paths from the wires, and here and there small arcs seemed to occur in the middle of the wood, and after a few moments the whole burst into flame. A block of salt about as large as a brick,

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when slightly damped offered free passage for the current, which played over its surface in brilliant yellow flames. A sheet of celluloid $\frac{1}{8}$in. thick broke down instantly, as did a sheet of ebonite of the same thickness. In these experiments the current did not break down or perforate the substances, but they behaved exactly like conductors. An experiment which was shown by Mr. Tesla, and which is often demonstrated by Messrs. Siemens, consisting of a sheet of glass placed between two flat terminals, was repeated by Messrs. Bourne. A blazing network of violet threads of fire darted out all over the glass, three or four arcs ran round the edge to the other terminal, and finally the glass was perforated and the edges of the small hole became white hot and fused together, the glass in its molten state being a conductor. The glass therefore appears to be a

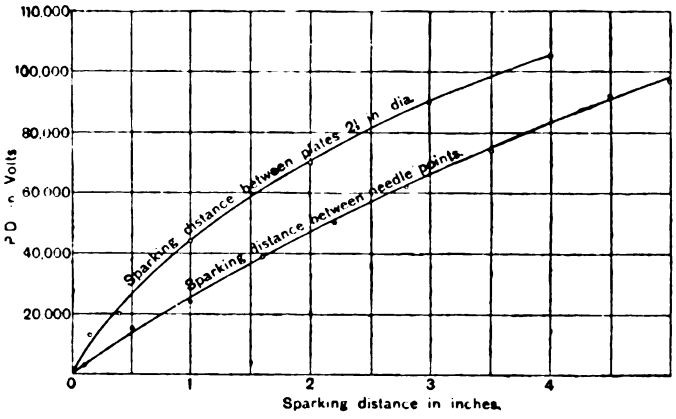

FIG. 1.

rival of oil in its self-healing properties. A specimen of good rubber-covered cable was shown. This had been wound with bare copper wire over a small portion, and subjected to 20,000 volts, acting as a concentric cable. The dielectric soon heated, owing, not to conduction but to absorption currents, and soon broke down and burned. The time element is of great importance in this case, and a very important difference exists between the effects of direct and alternating currents on insulators. Whenever, as in the case of a concentric cable, the two conductors are at all close together, we have a condenser which is being rapidly charged and discharged. Now in the case of most solid dielectrics there is a good deal of soaking in and consequent loss of energy, which manifests itself as heat. This was made very evident in the case of a condenser which was tried at Messrs. Swinburne's works. This condenser was made

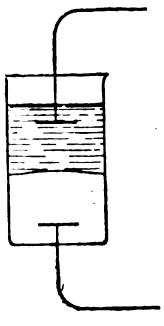

FIG. 2.

of sheets of tinfoil insulated with paper soaked in paraffin wax in the usual way; its insulation, measured with a steady pressure of 240 volts, was about 6 megohms, and the active service of plates was 5,000 square inches. When it was connected across a 2,000-volt circuit it was found to absorb more than a horse-power, so that a considerable rise of temperature was not surprising. But it was also noticed that its capacity rapidly diminished and finally disappeared, which was on investigation found to be owing to the fact that the foil had melted and so become disconnected from the circuit. Another condenser, made with glass plates $\frac{1}{10}$ inch thick, broke down with 2,000 volts after about five minutes, apparently owing to internal cracks caused by the heat evolved. In the case of the sample of rubber-covered wire above referred to, the compound in which the braiding had been soaked melted in five minutes, and the rubber became quite softened by the heat in about fifteen minutes.

The construction of transformers, condensers, and voltmeters for such high pressures would be hardly possible without oil insulation; and the authors of the Paper had a good deal to say about the use and behaviour of oil. It has been found that the heating due to absorption currents is very much less in liquids than in solids, probably because a shear strain cannot exist in a liquid. An expenditure of about $\frac{1}{4}$ watt per cubic inch of oil has been observed, and there is very little to choose between different kinds, those having a high specific inductive capacity seem to heat the most. When one electrode was placed at the bottom of a vessel containing oil, and the other, consisting of a wire, was placed just above the surface, the oil was violently repelled just below the wire, forming a depression of about $\frac{3}{4}$in. deep. A very interesting experiment with two different oils was shown. Coloured castor oil was poured into a glass beaker, and a layer of paraffin oil was floated above it. Flat-ended electrodes were connected to the transformer, and the surface of the castor oil was seen to rise or swell in a kind of hill in the middle (Fig. 2) It was suggested that this was due to the tendency for the capacity of the system to increase, the specific inductive capacity of castor oi lbeing greater than that of mineral oil. Drying by sodium, sodium amalgam, phosphoric acid, and other powerful dehydrating agents had been found to be of little benefit; but the breaking down distance in oil was greatly diminished by the presence of dust or other impurities, which placed themselves in line by electrostatic action, and formed a bridge.

Vacuum tube discharges were shown. To allow some 2 H.P. to pass, the terminals had to be large, rolls of aluminium foil were used for this purpose. The luminous effect was very small, as in Mr. Tesla's experiments, being not more, as far as one could roughly judge, than one candle or half a candle per H.-P. The frequency of the current used in these experiments was about 200 periods per second, and it thus appears that the efficiency of the light emitted by vacuum tube discharges of this frequency is extremely small. Mr. Tesla has not yet published any figures denoting the power absorbed in his glow lamps; but it must be remembered that the frequency of the currents he used was from 10,000 to 20,000 per second, so that the efficiency of his system of lighting may possibly be much higher.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

SATURDAY, March 19th.

ROYAL INSTITUTION.

3 p.m Afternoon Lecture: "Matter at Rest and in Motion By Lord Rayleigh, F.R.S.

MONDAY, March 21st.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. III.—4. "The Uses of Petroleum in Prime Movers." By Prof. William Robinson, Assoc. M.Inst.C.E.

TUESDAY, March 22nd.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read with a view to discussion: "On Mean or Average Annual Rainfall, and the Fluctuations to which it is subject." By Alexander R. Binnie, M.Inst.C.E.

WEDNESDAY, March 23rd.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Manufacture and Industrial Application of Flexible Tubing." By Gilbert R. Redgrave.

THURSDAY, March 24th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting.

FRIDAY, March 25th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "On the Electromotive Forces of Gold and Platinum Cells." By Prof. Herroun. (2) "On a New Instrument for showing the Effects of Persistance of Vision." By E. S. Bruce, M.A. (3) "Some Electrical Instruments." By R. W. Paul

OLD STUDENTS' ASSOCIATION.

7.30 p.m. Smoking Concert at the Masons Hall Tavern.

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SCIENTIFIC LITIGATION.

For fourteen days in the Law Courts, besides many consultations before and during this period, some dozen of our leading men of law, science, and electrical engineering, together with as many more assistants, have been arguing, examining, replying, repeating themselves, trying to lay traps for each other, quibbling, contradicting, explaining, insinuating, and generally playing at cross purposes. No less than nine thousand seven hundred and thirty questions were put and answered, unless, indeed, they were shirked, fenced, or equivocated. In mere expenditure of time and of words there was a sad waste. That is common enough in Parliament and elsewhere; the real prodigality here was in the squandering of intellectual energy. These men, nearly every one of them keen partisans, were drawn up on two sides, and each struggled to impede and undo the work of the other. So many able men pulling together in the same direction for this space of time might have achieved some great thing. What they have succeeded in doing has been to teach and unteach, to puzzle and to weary one of the most able Judges on the bench. Side issues have been numerous; the early history of electric lighting has been unfolded, and the evils of the system of expert evidence have been displayed. On a future occasion we shall discuss the object of the dispute and the nature of the case; but at present we shall confine ourselves to the procedure of which the case of "LANE FOX v. The Kensington and Knightsbridge Electric Lighting Company, Limited" has been the latest example.

Hard things have been said about expert witnesses; and while happily no wilful attempt was made to mislead the Judge, many of the abuses of the system were sufficiently

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evident. This case, tried by a non-scientific Judge, in consequence of the illness of a "brother" who is well versed in both pure and technical science, was in some respects a very striking example of one of the absurdities of our judicial system. The Judge, for we must for a moment particularize, who is well and justly celebrated for being one of the most painstaking and respected on the Bench, admitted with the utmost frankness his lack of acquaintance with electrical science. Yet this deficiency is not considered to present any serious practical difficulty. We would ask our readers to consider for one moment an ordinary commercial case tried by a senior wrangler who after a lifetime of strict specialisation in scientific matters was as little versed in financial affairs as the learned Judge is, or rather was, in electrical matters. Imagine the counsel in opening carefully explaining the meaning of a mortgage, describing the elementary principles of the formation of a public company, and sketching, with as few technicalities as possible, the difference between preference shares and debentures. Then after two or three days, imagine the Judge stopping the case to ask the difference between principal and interest, and whether a "share" meant a sum of money or a piece of stamped paper. The idea is ridiculous enough, but the parallel is by no means exaggerated. That the present method is held to be practicable is because the system of "instruction" of counsel by solicitors and of solicitors by their clients is blindly adhered to. The getting up of a scientific case devolves on one or two men on each side; and it frequently happens that their affidavits, after being carefully drawn up, are mangled by self-satisfied solicitors, and "proofs" are cut down and rearranged and so treated that the points are frittered down, and the case is hardly recognisable by the man who has prepared it; being reduced, in fact, to matter within the grasp of the counsel. Of course the clients and experts have plenty of opportunity for imparting their ideas direct to the counsel during consultations, but when has a patent case ever been tried at the termination of which one or both sides have not complained that they have been hammering this or that point at their counsel, who were quite unable to appreciate it? Allowance must, of course, be made for the fact that the mere spectator often thinks that he could have brought out a point or trapped a witness better than the counsel; but the fact remains that it is distinctly exceptional to find the essence of a scientific case fairly represented by the advocates. Cumbersome as is the system of "instruction," the ignorance of the lawyers is largely answerable both for the unsatisfactory way in which scientific cases are presented, and the tedious repetitions and waste of time which make such litigation so costly. There are only just enough scientific counsel for one case at a time; two important cases could not be carried on simultaneously. One well-known Q.C. seems to have dropped out of patent cases, while more than one young barrister of excellent scientific education and experience has never been seen in them. We hear much of the difficulty of rising at the bar, yet no juniors seem to make any effort to acquaint themselves with even the elementary science which is taught to first and second year students at a technical college. Of the hundreds of students that are turned out of these establishments, do any, finding the engineering profession over-crowded, realise that the barristers of the day who are, we will not say scientific, but capable of conducting scientific cases, may be counted on the fingers of one hand? What we have said of the Bar applies *à fortiori* to the Bench, though it must be confessed that, if the Court of Appeal and the House of Lords be included, there is a large proportion of Judges who are well able to try scientific cases.

But patent and technical cases generally differ from others in that the witnesses for the most part play a most important and peculiar part. The legal profession is fully alive to and in awe of the peculiar habits of the expert witness, whose ways are indeed proverbial. The witnesses themselves are by no means ignorant of the peculiarities of their class; but it must at once be admitted that the circumstances which are forced upon them by the existing legal procedure, combined with the weaknesses and proclivities of human nature, conduce to the results which are so frequently observed. The expert witness, in six examples out of seven, is a partisan of his side. Nothing else, of course, is to be expected when the plaintiff and the defendant appear in the box. In the *Nineteenth Century* for February, it is stated by Mr. Mead, in an article on "The Accused as a Witness," that Mr. Justice A. L. Smith has commented strongly upon the absence of the defendants as witnesses. In the case which has just closed, the learned Judge must at all events have been satisfied in this respect. He had before him the accused,—we beg pardon,—we mean the ostensible defendant, one of the principal shareholders of the defendant company, the secretary and engineer of the company, besides other subscribers to the defence. These were almost naturally keen partisans, and such witnesses are, of course, to be found in nearly every case. But we find some excuse for the partiality, even of the professors and others who appear simply as expert witnesses. No excuse is deemed necessary for solicitors or barristers, because it is by advocacy that they earn their bread,—as though experts went there for the fun of the thing! After even the first consultation it is difficult for such a witness to maintain an impartial attitude of mind. He is expected to study and to put forward the strong points of the side which retains his services, and to discover the weak points of the other; and while he cannot but recognise that his case has its weak points, and that his opponents possess some strong ones, he is naturally tempted to bolster up the former, and endeavours to shake the latter. This state of things strongly conduces to partisanship; and it needs a distinct, and often a strong effort to keep an unprejudiced attitude worthy of a man of science. As the case proceeds, how can the expert help prompting his counsel when a witness on the other side makes a mistake? or how can he refrain from suggesting questions for cross-examination? Those of the legal profession who say hard things of the expert witness seem to imagine that they could dispense with nearly all his services but those which he renders while actually in the box; and one of the many suggestions that might be made with a view of reforming the present system is the exclusion of the expert witness from consultations both before and during the case, just as is done under existing practice during the period which elapses between the beginning and end of his evidence.

It is easy to propose improved systems too radical to stand any chance of adoption; but while the present law specially provides that the Court has power to, and on the request of either party it must, call in the aid of an assessor specially qualified, and try and hear the case wholly or partially with his assistance, it is a marvel that recourse is so rarely had to this obvious privilege. It should not be difficult to choose such an assessor; for it is only necessary that he should have a fair scientific and practical knowledge of the subject, and have sufficient acquaintance with patent law, to refrain from meddling. It has been proposed that the Judge should confine himself to the points of law, while the scientific issues are decided by a jury of experts, paid by the Court for their services, but expected to be thoroughly impartial. It is held that patent actions can, as a rule, be more satisfactorily disposed of by a Judge without

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a jury; for questions of law and fact are generally intimately connected, and much of the evidence relates to matters of opinion. An expert jury would, however, be able to appreciate facts which neither counsel or Judge could be expected to comprehend, such, for example, as the drop in a transformer due to resistance, while their views about matters of scientific opinion would be equally valuable. They might act as referees for witnessing experiments, and put an end to one of the most deplorable features of modern patent cases, viz., the carrying out of experiments for the purpose of backing up a particular contention, and the inevitable so-called repetition of the experiments by the other side, if the case is long enough, with absolutely contradictory results. Such a jury would resemble a Royal Commission, and its usefulness might be greatly increased by permitting the members to examine the witnesses on the technical points. After a patent case is over, experts from each side will sometimes quietly discuss for their own satisfaction, and settle in a few minutes, a matter which has been wrangled over for days. The plaintiff and the defendant, where the former is an inventor and the latter is alleged to infringe, should both appear and be examined by the jury or scientific commission in the presence of the Judge. If a single arbitrator were selected to decide on the points of law, many patent cases could thus be decided out of court at a reasonable expense.

NOTES ON SUBMARINE CABLE WORK.

BY H. D. WILKINSON.

(*Continued from page 489.*)

5. **Cable Inboard.**—While grappling, the strain is indicated on a dynamometer on board. One type of dynamometer in use is shown in Fig. 18. The grapnel rope is taken on the under side of a sheave or pulley on the apparatus, free to revolve as

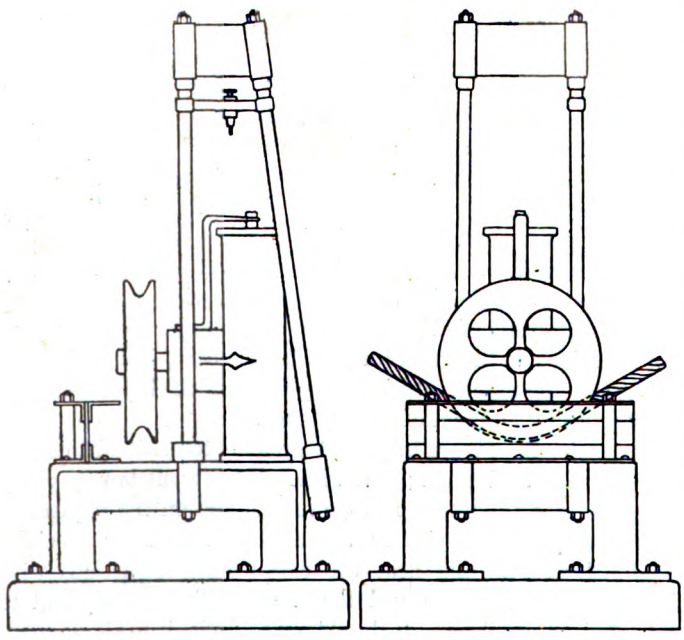

Fig. 18.—Ship Dynamometer.

the rope is paid out or picked up, and the rope is led down to the sheave at an angle and up again the other side, so that any strain on the rope tends to raise the sheave. For this purpose the axle of the sheave is mounted in a single bearing on a block capable of a vertical motion between guides, and the upward movement of the block and sheave is counteracted either by a spring or a plunger working in a cylinder filled with a mixture of water and soap or oil. In the dynamometer illustrated a cylinder and plunger brake is used, the piston rod having fixed at its top end a connecting rod coming down outside the cylinder on to the moveable block. The speed of the piston and the calibration of the apparatus is adjusted by the valve V in a pipe leading into the top and bottom of the cylinder, as shown in Fig. 18A. The resisting liquid inside the cylinder can be

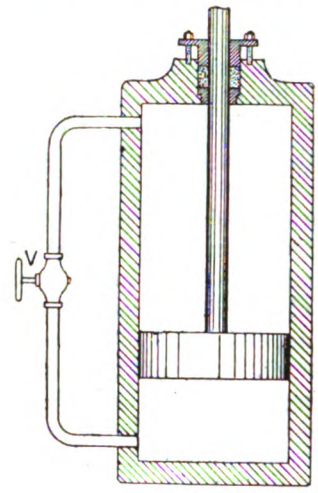

Fig. 18A.

made to brake the movement of the piston to any required amount by opening or closing the valve V at the side, and letting more or less pass through the pipe. A vertical scale is fixed on the dynamometer, calibrated in hundredweights and tons strain, but is not shown in the engraving in order not to obscure the working parts. The grapnel rope passes over one of the bow sheaves, over a loose guide pulley, under the dynamometer sheave, over another guide pulley, and then has three turns round the picking-up drum attached to a shaft driven by a steam engine. The drum is held by a powerful brake while grappling, and the ship, which is travelling only at the rate of two or three knots an hour, is stopped immediately the strain indicated on the dynamometer gives reason to believe that the cable is hooked. It happens occasionally that the cry of "Stop the ship!" is given when some jerk or strain occurs which turns out not to have been caused by the cable. Rocks, beds of coral, and deep-sea growths all impede the steady travel of the grapnel along the ocean bed, and cause heavy strains to be indicated at times.

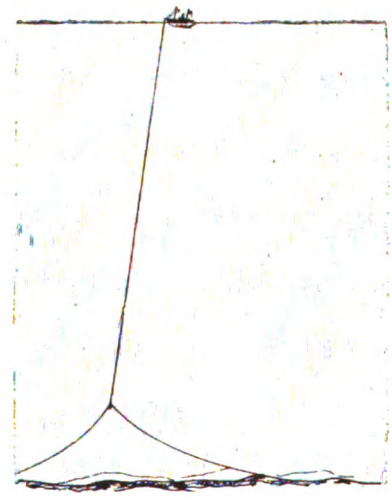

Fig. 19.—Raising Cable in 800 Fathoms.

An experienced hand will tell when the cable is hooked with an almost dead certainty by sitting on the grapnel rope near the bows. Of course it is not uncommon to heave up after some heavy strain on the rope and find that the prongs have been bent or torn off by some obstruction below. In that case new prongs are slipped on or another grapnel substituted. It is no waste of time to heave up and see that everything is

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right, even though the fact that the strain is not increased as heaving up goes on makes it pretty certain that the cable is not on. If this was not done after a heavy strain the situation might be somewhat similar to that of the bottom-fishing individual who, more interested in the gallon jars surrounding his comfortable chair in the punt, doses off for an hour, rod in hand, with no worm at the other end. It is true in cable work, as in other kinds of engineering, that nothing is so certain to happen as the uncertain. Even when it is known, by the gradually increasing strain on the rope on heaving in that the cable is on the grapnel, it is always an anxious time, for the cable may be buried and the strain cause it to part at any moment. If breakage occurs the ship must steam to a fresh position three or four miles further on and commence again. When parted in this manner the length of the grapnel rope heaved in after the occurrence is measured, and a note made of the depth at which it parted; or it may part below water when in sight at the bows, or one end may be lost after the stoppers are put on.

Cables are purposely armoured with a heavy sheathing of iron or steel wires, in order to give great tensile strength to sustain several times their weight when being raised from the bottom during repair. But this very protection is subject to many deteriorating conditions, and frequently is a source of great trouble. The writer has seen cable coming in board with the sheathing in a very ragged condition, the first cause having been attributed to corrosion of the wires through oxidation in places were the preservative compound has worn off, or direct galvanic action in places that have been in contact with

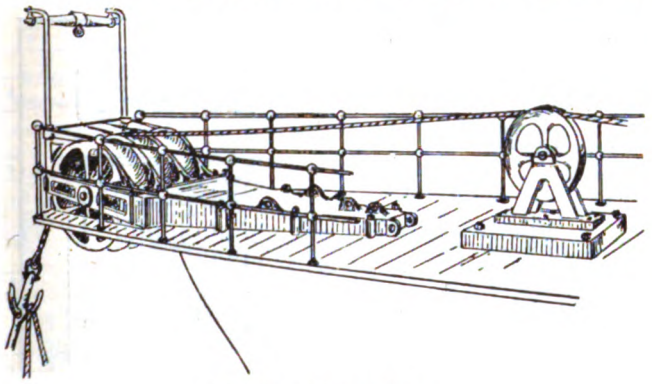

Fig. 20.—Cable at Bows.

metalliferous veins in the ocean bed. In other cases it has been ascertained to be due to abrasion against sharp projections in the ocean bed where the depth increases very suddenly, as, for instance, near the Nicobar Islands, in the Indian Ocean. The wires, so broken, leave the strain to be borne by the core, which it is seldom able to support without rupture, or damage is caused by the ends of the broken wires pressing into the core. It has been suggested from time to time to do without the iron sheathing wires altogether, and depend alone upon a hemp covering; but although there are many points in favour of this construction, there has been found some difficulty in sinking such cables during laying and grappling for them afterwards, while considerable shrinkage occurs with detriment to the core.

To afford some idea of the depth from which cables are picked up, a sketch is given in Fig. 19, showing the relative size of a cable ship 240ft. long, picking up cable in 800 fathoms. Depths, of course, vary a great deal, and repairs are more frequent in depths under 1,000 fathoms; but it is no uncommon occurrence now to raise cable from a depth of 2,000 fathoms or two and a-half times the relative depth shown in the sketch. The cable as it appears at the bows hooked on to one of the grapnel prongs is shown in Fig. 20. When fairly in view the heaving-in engine is stopped, the winding-drum braked, and a boat lowered with two or three hands to put stoppers on the cable. Two ropes are led over the bow sheaves for stoppering on to the cable, one on each side of the bight caught by the grapnel, and after these are made fast they are heaved in on one drum geared to the engine, while the other drum with the grapnel rope is thrown out of gear. The bight of the cable is then hauled on board, and the grapnel and grapnel rope being relieved from the strain are taken in. As soon as the bight appears on board at the bows a man is ready with a hack-saw and cuts it through, the ends being bared and the copper conductors connected on by binding screws to a pair of insulated wires leading from the bows to the testing-room. These are numbered one and two, and the stations on shore to which the cable ends belong is seen by the way the cable is bearing, so that it is known in the testing-room which station is on each wire. The act of cutting the cable generally produces currents or disturbs the earth or polarization currents in such a manner as to produce "kicks" or jerky signals on the mirror instruments on shore, so that some intimation of the ship having got the cable is generally to be noticed before she actually calls up.

From the moment the cable is at the bows the busiest time for the chief electrician and his assistant begins. He may be occupied but a couple of days before completing the repairs, or he may be three weeks. There is no telling till the first test is taken and picking up commences. The cable may be buried in coral and keep breaking, or the fault may be a very difficult one to localise, and be really much further off than it appears. At all events, right through the job it is continuous work day and night, with frequent testing and record-keeping of times, lengths picked up and paid out, and messages to be received and sent to keep the head office informed of the ship's movements. It may be said, as indeed it is the case, and necessarily so, that the ship's movements are under the chief electrician's orders from the moment the cable is at the bows; and the responsibility is one of no small importance.

No time has now to be lost to find out by tests on the two ends towards which direction the fault lies, and to acquaint the officer on watch which end is to be buoyed. To do this the distant ends on shore must in turn be "freed." Each end in the testing room, is then joined up in turn to the speaking-mirror connections, the station called up and asked to "free one minute" or thirty seconds; and as soon as the reply from shore comes, "O K, done," the end is instantly put over to the testing connections and the test taken. The test is simply the passing of a current direct through a marine reflecting galvanometer to the cable. If the insulation is good very little current passes; if faulty, the deflection of the instrument is large, allowing, of course, for the relative lengths of cable on each end. If the fault is very small, and polarises quickly, or the cable is known to have a length or more of low insulation cable spliced into it so as to bring down the general insulation resistance, the difference between the deflections or the insulation of the two sections may not be so great, especially if the fault is on the shorter length. It may, therefore, be necessary to repeat the tests again after this is found out; but, generally speaking, the faulty side shows itself on the first test. The other end has then to be moored and buoyed, and the ship's officer is informed at once which end is to be prepared for buoying. Meantime it is necessary to form an idea how long it will take to remove the fault, and about what time the ship will be back to the buoy again, because there is no need for the station on the buoyed end to put their men on watch again until such time as the ship returns to the buoy after removing the fault on the other end. This time is estimated by the electrician, by deciding there and then approximately how far the fault is off. If he makes it five miles off and the time is about noon on, say, Monday, he will send a message to the superintendent at this station: "Now buoy your end, keep watch after 6 a.m. Tuesday." While to the other end a message is sent: "Now buoy —— end and pick up towards ——, keep watch night and day." A message is also sent direct to the head office, giving information as to the time of arriving at position of fault, time got cable, number of miles away from shore where cable was cut, and estimated distance of fault. These messages being sent, the electrician emerges from his testing-room to find that everything has been got ready to moor the cable and buoy it; and he has only to give the word that he is ready to buoy, when the cable end is at once lowered and moored, and the buoy with the mooring chain floated.

(To be continued.)

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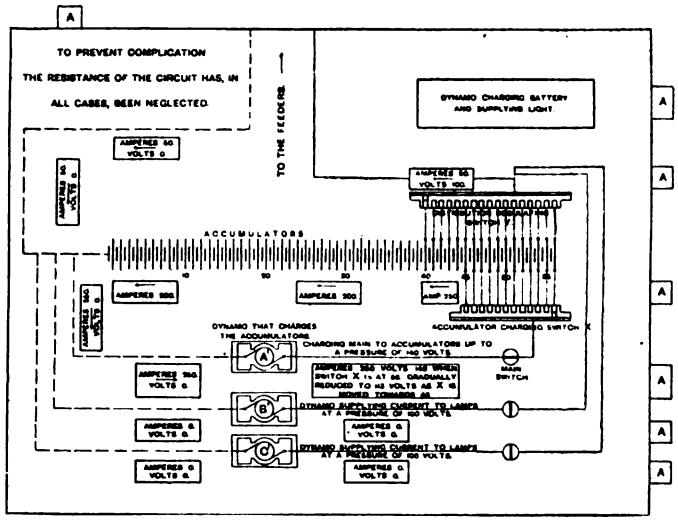
SECONDARY BATTERIES FOR CENTRAL STATIONS.

The method of working the secondary batteries at the station of the Kensington and Knightsbridge Electric Supply Company was described and discussed in the long patent case of Lane Fox *v.* that Company with the aid of an elaborate model, provided with shifting labels, mounted on polygonal rollers. This model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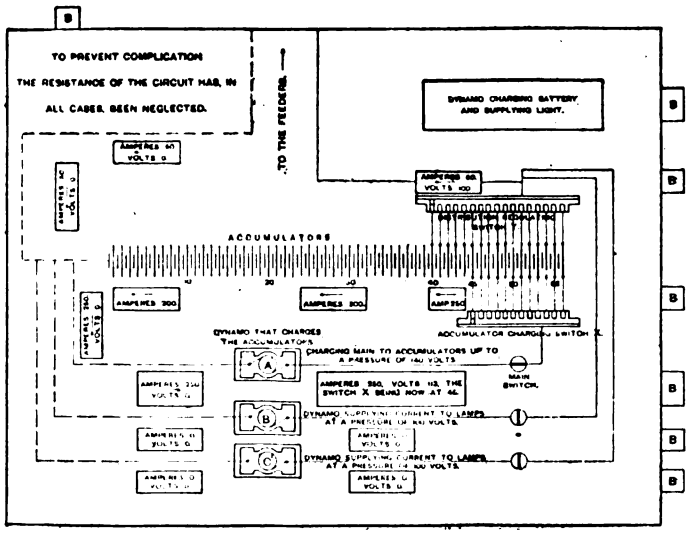
DYNAMO THAT CHARGES THE ACCUMULATORS
CHARGING MAIN TO ACCUMULATORS UP TO A PRESSURE OF 140 VOLTS
ACCUMULATOR CHARGING SWITCH X
MAIN SWITCH
DYNAMO SUPPLYING CURRENT TO LAMPS AT A PRESSURE OF 100 VOLTS
DYNAMO SUPPLYING CURRENT TO LAMPS AT A PRESSURE OF 100 VOLTS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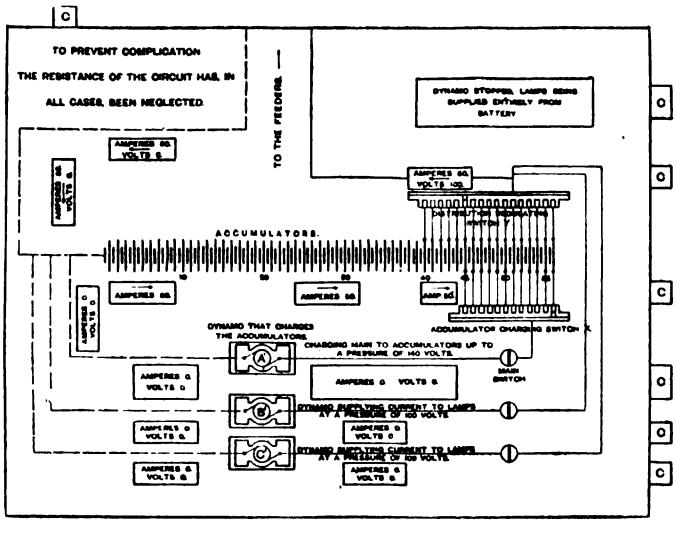
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DYNAMO STOPPER LAMPS BEING SUPPLIED ENTIRELY FROM BATTERY
ACCUMULATORS
DYNAMO THAT CHARGES THE ACCUMULATORS
CHARGING MAIN TO ACCUMULATORS UP TO A PRESSURE OF 140 VOLTS
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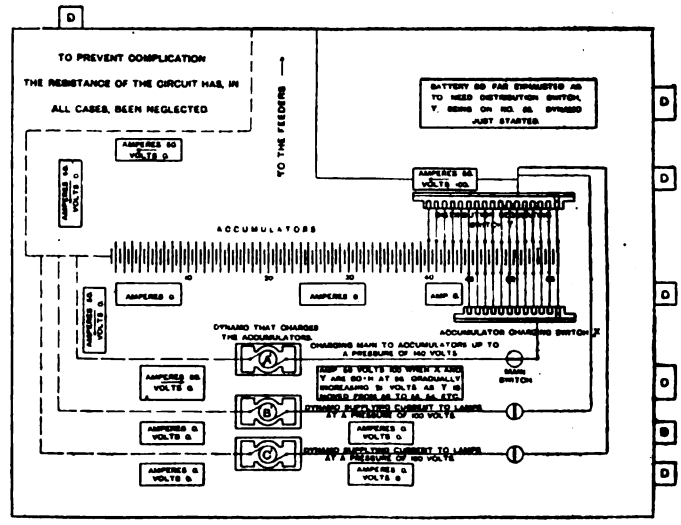
MAIN SWITCH
DYNAMO SUPPLYING CURRENT TO LAMPS AT A PRESSURE OF 100 VOLTS
DYNAMO SUPPLYING CURRENT TO LAMPS AT A PRESSURE OF 100 VOLTS

was constructed under the direction of Sir F. Bramwell, from information supplied by Mr. Miller, the engineer of the Company. It does not represent accurately the particular mode employed, but shows generally the system which has been developed by Mr. Crompton. Seven different positions of the labels are shown in the accompanying diagrams, The rollers are provided with polygonal handles, bearing the letters A B C, &c. These are indicated at the side of the diagram. Several witnesses were examined on this model, which was generally placed on the Judge's desk, the witness standing by his side to move the switches, &c. The examination of Dr. Hopkinson relating to this will be found in our report of the case.

A.—A shows dynamo A' alone at work, delivering amperes 250,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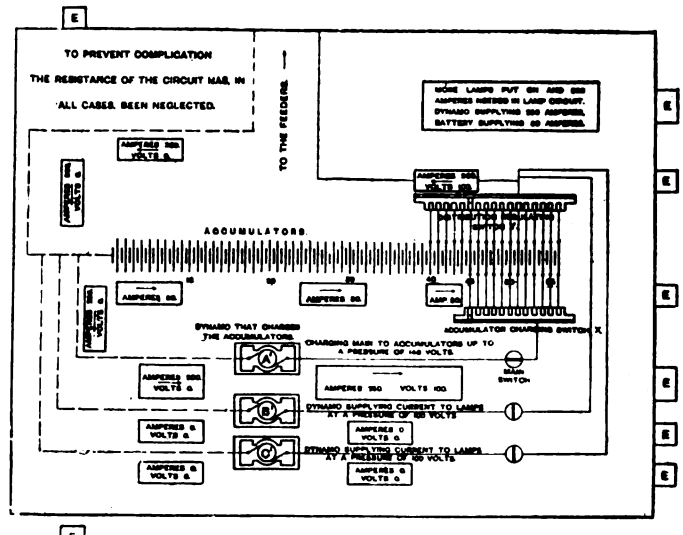
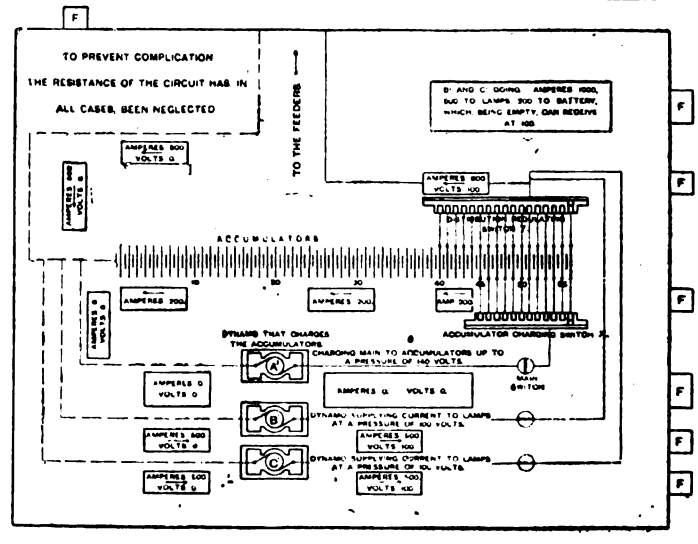

E
TO PREVENT COMPLICATION
THE RESISTANCE OF THE CIRCUIT HAS, IN
ALL CASES, BEEN NEGLECTED
TO THE FEEDERS
ACCUMULATORS
DYNAMO THAT CHARGES THE ACCUMULATORS
CHARGING MAIN TO ACCUMULATORS UP TO A PRESSURE OF 140 VOLTS
ACCUMULATOR CHARGING SWITCH X
MAIN SWITCH
DYNAMO SUPPLYING CURRENT TO LAMPS AT A PRESSURE OF 100 VOLTS
DYNAMO SUPPLYING CURRENT TO LAMPS AT A PRESSURE OF 100 VOLTS


F
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DYNAMO SUPPLYING CURRENT TO LAMPS AT A PRESSURE OF 100 VOLTS

volts 140; the pressure of 140 volts being needed because, in order to charge the whole length of the battery, the charging switch X is at cell 56, and 140 volts are required (with rapid charging) to overcome the resistance of 56 cells; but as 100 volts is the assumed proper pressure for the lamp circuit, the switch Y is placed at cell 40, at which point, owing to the

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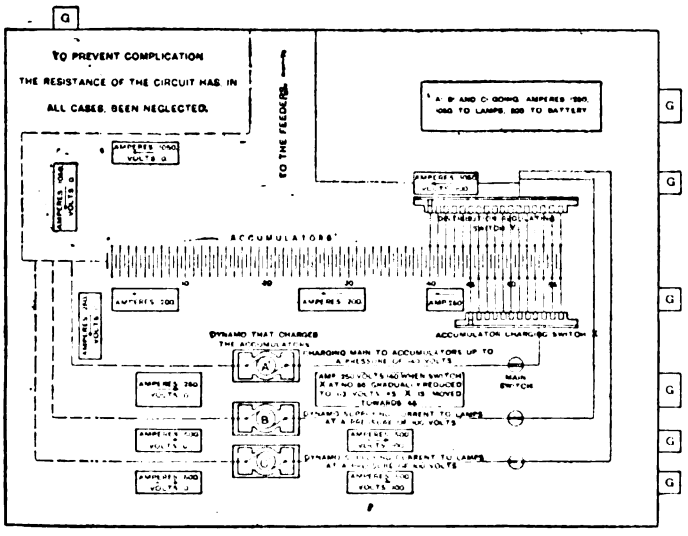
resistance of the 16 cells 56 to 40, the 140 volts are reduced to the 100. The lamps at this time require 50 amperes, so that at cell 40 50 of the 250 amperes go to the lamps and the remaining 200 go to the battery. There will be seen on the tablet a statement as to how the 140 volts are gradually reduced to 113, as the high-numbered cells of the battery are charged, and the switch X is moved in succession from 56 to 55, &c., down to 45.

B.—This might have been omitted, for it is nothing more than A in its last stage, namely, when the switch X is down to cell 45. It will be understood that the 13 volts above the 100 which prevail at 45 are absorbed, as it were, in passing through the five cells 45 to 40, so that at cell 40 the needed 100 volts for the lamps still prevail.

C.—All the dynamos are now stopped and the lamps are being supplied from the battery only, the switch Y being at cell 45. The transition from B to this condition of things has been a gradual one. When the battery was about fully charged, the dynamo A′ was caused to give less and less amperes and less and less voltage, until 100 volts were reached. Shortly before the stoppage of the dynamo A′, the battery began to contribute to the supply of the lamps; on its final stoppage the whole of the current, 50 amperes (*see* the reverse direction of the arrows at the battery), is given from the battery. This condition of the supply goes on; the battery pressure falling off, involving as it falls off the gradual movement of switch Y from cell 45 up to finally cell 56. Beyond this point, the battery cannot do the work, because the pressure would fall too low.



D shows this last-mentioned condition of things and the re-starting of the dynamo A′. To begin with, the switch X is put at 56—that is to say, exactly opposite the switch Y, and the dynamo A′ is delivering the 50 amperes needed for the lamps at 100 volts only, as the current goes straight across from X to Y; but as the object is to do now that which was done in A, viz., supply the lamps and re-charge the battery, the amperes from the dynamo are gradually increased, and the pressure is gradually increased, involving the moving of the switch Y gradually from 56 towards 40, so as to preserve the pressure of 100 volts for the lamps; while the higher-numbered cells become charged the switch X is also gradually moved from cell 56 towards cell 45. It will be observed that the tablets at the battery indicate amperes 0. This is true when the dynamo is first started; but as its output of 50 amperes is increased, the whole excess of the output above 50 goes to the battery.

E.—This assumes that more lamps have been put on, and that 300 amperes are needed in the circuit. The dynamo A′ being competent to supply only 250, the balance of 50 has to come out of the battery. Both switches, X and Y, are now at cell 45; the dynamo pressure is kept down to 100 volts, as the 250 amperes from the dynamo go straight across at 45 to the lamp circuit. As the battery discharges, and the pressure would therefore fall, the switch Y is moved from 45 upwars towards 56; and as the 250 amperes are going direct from the dynamo to the lights, it follows that the switch X must at all times be on the same cell as switch Y.

F assumes that so many more lamps have been put on that 800 amperes are needed for them. It also assumes that the dynamo A′ is stopped, and that B′ and C′ are put to work, each giving 500 amperes (making 1,000 in all) at 100 volts, of which 800 amperes go direct to the lamps, the remaining 200 being dealt with as follows:—As the battery is entirely empty, it can be charged at 100 volts, not by the switch X, which was formerly used when the dynamo A′ was at work, but by putting the switch Y up to cell 56, to act under this condition as a charging switch. As the pressure in the battery rises, involving, therefore, unless an alteration were made, an increase of pressure from dynamos B′ and C′ (a condition of things which would be incompatible with the maintenance of the 100 volts in the lamp circuit), the switch Y is gradually moved from 56 to the lower numbers; and thus, although the pressure remains at 100 volts, the charging of so much of the battery as is to the left hand of switch Y can still go on. It will be seen that under this arrangement the higher numbers of cells can never become fully charged.

G assumes that the lamps now require 1,050 amperes, and that the battery has to be recharged by 200 amperes, making 1,250 in all, *i.e.*, the total product of the three dynamos A′, B′, and C′, which are therefore now all running. It will be seen that the working of the dynamo A is precisely the same as in position A, and in fact the operations during G are the same as those during A, except that the dynamos B′ and C′ being at work are sending 1,000 amperes direct to the lamp circuit to augment the 50 which it will be seen in A came from the dynamo A′.

NOTES ON AMERICAN DYNAMO PRACTICE.

BY J. D. DALLAS.

Going through the Crystal Palace Electrical Exhibition the first point that would strike an American electrical engineer is the absence, generally speaking, of self-oiling bearings. In America, except for alternators and arc-light dynamos, the best types of machines are always so fitted. The general design is a cast-iron or brass shell, resting in a spherical seat in the cast-iron standard, and provided with two partial slots in the shell, extending so far down as to allow of brass or other rings to sit on the shaft. When in motion these rings are caused to rotate by the friction on the shaft, and as they dip down below into the oil wells cause a continuous and steady supply of oil to the bearing. The spherical seat and shell are usually babbited. The one great objection which is always raised to this class of bearing is that the oil is liable to become rapidly "gummy." This, however, is not the experience of American engineers. The advantages of this type of bearing can best be appreciated by those who have had experience of both.

Compound dynamos in the United States are, of course, only used for isolated as distinct from central-station work for incandescent lighting, but generators so wound are likewise universally used for railway and tramway power stations. The shunt field circuits have nearly, without exception, rheostats inserted for a purpose to which reference will hereafter be made. The series coil is shunted very generally either by an adjustable German silver strip, or use is made of a so-called shunt board, wound with coils of insulated copper wire. The latter method is employed by one large company, six stops or contact points being provided, allowing of the grouping of the coils in nine different combinations. By cutting out more or less points less or more current is shunted from the series coils, thus increasing or decreasing respectively the ampere turns on the series field. The machines are, of course, designed to be operated with the full shunt board in circuit. But to suit the various uses to which the machine may be put after leaving the factory these stops are provided, so that a dynamo may be either compound or over-compound, as desired, the dynamo being readily and rapidly adjusted to the particular requirements of the situation. In

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different parts of the country different falls of potential are allowed in the mains and lead wires. Thus a machine might be installed in a building with a 5 per cent. loss at full load, 2½ per cent. on the mains, and 2½ per cent. on the leads.

To instal a machine exactly compounded in any such building would be useless, as one of the three following devices would have to be resorted to:—(1) To bring the potential difference of the machine up to 115·5 volts (if the lamps were of 110 volts), so that at full load the lamps might be burning up to full candle-power; this would, of course, break lamps in very short order. (2) The machine might be left at 110 volts for all loads, which at full load would bring the furthest lamps down to a potential of 104·7 volts; or (3) the potential might be adjusted to 113 volts. In each of these three cases the regulation would be wretched. With an adjustable shunt the dynamo can be put to the position where the machine is either 1, 2, 3, 5, &c., per cent. over compound, and with whatever drop the wiring has been designed the lamps will be at all loads within one volt of their proper potential—that is to say, if the mains are properly designed. It is not contended that 5 per cent. is either a right or a proper loss to allow, nor is it contended that it is usual; but such cases frequently occur. The loss on the mains is determined by the contractors and local inspectors of the Board of Fire Underwriters. It may be contended that such a shunt to the series coil is wasteful; on the contrary, the percentage of watts lost is but a very small percentage of the total loss in the machine. The reason the shunt coil circuit has a rheostat inserted is that the potential of lamps which may be nominally 110 volts may vary from 105 volts up to 112 volts or 114 volts; and as it would not be convenient to make a different machine for each small difference of potential one standard is generally used, the shunt field being adjusted to the exact potential when the machine is installed, the rheostat being fixed in this position.

The Edison General Electric Company always compound their machines at 125 volts. By varying the shunt field the potential may be reduced to any point from about 105 volts up to the normal, and still be compounded, the over-compounding being adjusted by means of the shunt on the series coil. If an English firm were to think of competing for some of the enormous business in the United States, they would have in some way to modify their practice so as to conform to the general American usage. Generators, which in England would be first-class machines, might possibly be failures in America for one or other of the above reasons. Truly, the potential of a machine may be varied by altering the speed; but this expedient is seldom or never resorted to.

The writer, during several years' residence in the United States, can only recall two instances, both in New York, in which English-manufactured dynamos were met with. In one case several machines of the Siemens type were used for telegraphic work in the Western Union Building. In the other case it was a small dynamo of the Elwell-Parker type.

At least one great company in America constructs all the spiders and heads in the case of ring armatures, and the heads in the case of drum armatures, of brass or composition. As precise figures of the gain at different loads are not at hand, it may be briefly stated here that the advantages are very appreciable, resulting in increased output due to smaller core losses with the same rise in temperature. To obtain such advantages, of course, the design must be very carefully carried out. The commercial efficiencies of different sizes of machines have in every case been raised. An American engineer does not look in the first place to a machine with a very high electrical efficiency, but rather to one of a high commercial efficiency, as the C^2R losses in a machine constitute but a fraction of the total losses.

Generators for alternating currents made by one company are now all compounded, the machines themselves being either self or separately excited, the total current when commuted being used for the purposes of compounding. Such machines give very excellent regulation. The present tendency seems to be using ironclad armatures, and still more recently to alternators with armatures having no wires revolving, both the field and armature coils being stationary.

Speaking again of direct-current generators, a point which at once would call for remark, is the fact that in so few cases is any lead given to the connecting wires to the commutator of two-pole machines. The chief objection is that it is difficult at first sight to see whether the lower brush is set evenly. Absence of sparking does not necessarily prove that the setting is correct.

THE CHICAGO EXHIBITION.

The following is a report of a meeting promoted by the London Chamber of Commerce, which was held on Friday afternoon, March 11th, at the Mansion House, by kind permission of the Lord Mayor, to consider the British representation at the Chicago Exhibition.

The Lord Mayor, in opening the proceedings, said he had been asked to take the chair at this meeting, the object of which was, he thought, of the utmost national importance, viz., to see what could be done to further in any way the movement for securing that Great Britain should be properly represented at the forthcoming Chicago Exhibition. Having regard to the keen competition of the Americans, Germans, and other countries, it certainly behoved this country to be thoroughly well represented. All European countries were giving their Commissions substantial grants. There was scarcely a movement of any importance which had not deficiencies connected with it; and the great deficiency, in this instance, was the McKinley tariff. That certainly did not ease the way; but it, of course, only applied to America itself; and, inasmuch as the visitors would come from all parts of the globe, it was worth consideration, by the manufacturers of this country, whether it would not be well worth their while to send forward their exhibits, with a view to retaining and enlarging the number of their customers all over the globe.

Sir Henry Trueman Wood said a sufficient number of the representative firms had sent in their names to the Royal Commission, to make it quite certain that this country would be not inadequately represented, and further that, considering not only the exhibits from the mother country, but those coming from the various colonies and India, the British Empire would be as well represented as it had ever been at any previous Exhibition. The McKinley tariff was, after all, not such a very large increase on the Customs duties which had been maintained in America for many years. Then the tariff only affected half of the imports into the States, and with regard to one-half of the remainder, or one-fourth of the whole, it could have practically but small effect, because the goods therein comprised could not be made in the United States at all. It was by no means certain either that this tariff would be permanent. The statistics, so far as they were available, showed a falling off in British exports during the past year, but it was almost as marked in the exports to other countries as to America. This went to show that a very small proportion of this loss was due to that tariff. With regard to the distance, no doubt it involved a journey of 3,000 miles by water, and 1,000 miles by land, but this was minimised by the fact that the Royal Commission had obtained special and considerably diminished rates of freight, both by land and sea, and the American railways would also make a considerable reduction in their charges. No doubt the work of the Royal Commission would have been easier if they had had larger funds at their disposal. They could only say that they had this amount to administer, and would do so to the best of their ability; but the meeting should understand that it was an absolute necessity that additional charges should be made on the exhibits if the country were to be adequately represented. All experience showed that £25,000, however economically expended, was not sufficient to defray the legitimate expenses of a section at a foreign Exhibition. Additional funds must come from somewhere, and there was no other source except the exhibitors—those who made special profits by exhibiting. The Americans themselves looked on this Exhibition as a magnificent opportunity for robbing us of our South American trade; and they were doing their best, quite legitimately from their point of view, to take it away from us, and we must do our best to prevent them. Other countries were doing the same. It was our bounden duty to struggle to the utmost not to lose such a magnificent opportunity for advertising English industries in the presence of the great American world, and that vast crowd of exhibitors from all parts of the world who would be certain to congregate next year at Chicago.

Sir Philip Cunliffe-Owen said he ought to apologise for speaking at all, for he was an Exhibition man of the past, and they were considering an Exhibition of the future. Still there was some of the old spirit left in him yet. He did not like the idea of England being beaten by the Americans or anyone else. He was quite sure we had only to show what we could do, and we should carry the world with us. He hoped people would not be frightened at the McKinley tariff, which was held up as a bugbear. He believed that before the Exhibition was half over the tariff would be torn to pieces, because the American people would insist on

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having their goods at proper prices. They learned some of the real price of goods on their visit to this country; but when they saw the prices marked on the goods in the Exhibition, they would insist on having the goods at the proper prices from the old country which had served them so well. He took it this was the final effort, and we were bound to show our relatives in America that we were still alive, and were not going to be superseded by the Germans.

Mr. M'CORMICK (European representative of the Chicago Exhibition Executive Committee) said reference had been made to the effect of the M'Kinley tariff on the trade with America; most present knew probably, though they might have forgotten it, that the Americans were, far away, England's best customers; for in the first nine months of last year, during the operations of the M'Kinley tariff, there were over £21,000,000 sterling in manufactured articles sent to America; whilst Germany, the next best customer, took about £14,000,000. That was a trade which England could well afford to cultivate. He might also say that what America knew about tariffs she had learnt from England. It was only a few years ago that England abolished the tariff, and that was when she felt herself strong enough to throw down her gauntlet to the world. America had never gone so far as England had in protecting her woollen trade. She had never placed an embargo on the export of cotton, which might have been done if there was anything hostile in the passage of a Tariff Act; but had allowed England to take American cotton, manufacture it, and send it back again, paying the freight on it both ways to English carriers. He hoped that when he returned to Chicago, at the opening of the Exhibition, he should be able to feel proud, not only of the exhibits of his own country, but equally proud of those furnished by Great Britain, and to congratulate his friends of the Royal Commission on the good work he was sure they would accomplish.

Sir DOUGLAS GALTON said he believed they would have an opportunity there, which was not allowed at Philadelphia, of stating on the exhibits what the price would be apart from the duty. If this were allowed, it could hardly fail to strike a serious blow at the McKinley tariff.

Sir OWEN BURNE hoped all present would take to heart what had been said, and that there would be a good British exhibit. He wanted all to put their shoulders to the wheel, and bring out Old England in the position she ought to occupy, especially as this might be our last struggle to maintain our place in the commerce of the world.

Sir A. K. ROLLIT, M.P., said there was a great deal of justifiable feeling about the McKinley tariff, but there was hope it would not be permanent. Already some concessions had been made which should be appreciated. He had reason to believe that the real true price at which articles could be obtained in England, irrespective of duty, would be allowed to be marked upon them, which would be certainly a benefit to the exhibitors of this country. It would prevent any misapprehension, and might illustrate certain economical principles for the benefit of America. The official date for applications to exhibit had passed, but there was still some space left, although it was rapidly being occupied, so that early application was necessary.

A vote of thanks to the Lord Mayor having been carried by acclamation, the proceedings terminated.

SOME EXPERIMENTAL INVESTIGATIONS OF ALTERNATE CURRENTS.

The following is the authorised abstract of the concluding portion of the discussion on Mr. Alexander Siemens' Paper at the Institution of Electrical Engineers, which took place on Thursday, 10th inst.:—

Mr. HOUSMAN referred to some curves in Mr. Siemens' Paper showing that the loss by hysteresis increased with the number of $\sim$ per second. These curves were, he pointed out, the loss by hysteresis *per second* and not per cycle; if the latter value were plotted it would be found that the loss per cycle decreased very materially with increase of $\sim$. This he confirmed by experiments of his own with low frequencies varying from 3 to 30 $\sim$ per second.

Mr. RUSSELL had tried many experiments to see if a spark micrometer could be relied on as a rough voltmeter for an induction coil spark, and had come to the conclusion that it was quite unreliable, the results varying 5 to 10 per cent., even when the greatest care was taken to polish the electrodes. He also showed some curves of sparking distances between balls, spears, and points. Unlike Mr. Siemens he had found a very great difference with differently shaped electrodes; the sparking distance being at 2,000 volts three times as great between two spears as between a spear and a ball, and the ratio increased as the volts were raised. In no case did he get so short a distance as Mr. Siemens. He had found that time had a very distinct effect on sparking distance. An E.M.F. which would not cause a spark at once would often do so if left on for one or two minutes. He objected to the expression of sparking distance in volts per millimetre. All the curves of sparking distance with various volts were convex (to the axis along which E.M.F. was taken), *i.e.*, the volts per millimetre decreased as the volts themselves rose; in some of the curves to as much as 25 per cent.

Mr. ESSON suggested that it would be well in the cable transformer to bring the two ends together and get a closed iron circuit. He also showed some curves giving the all-day efficiency of two transformers, the one with the copper loss three times that in the iron, and the other with the iron loss three times that in the copper. The all-day efficiency of the latter appeared to be nearly twice as great as that in the former, both curves were based on the average load curve of the Kensington Court Station.

Mr. SIEMENS, in reply, said that Prof. Perry had thrown some doubt on the temperature determinations because they depended on the measurement of ·002 ohm in ·7 ohm. He could assure him that there was no difficulty in making such a measurement to that degree of accuracy, and that it was done every day in practice. Mr. Evershed had also doubted the accuracy of the method; but he, the speaker, would point out that it was a very well known and tested one, being in fact nothing but that of the electrical thermometer of the late Sir W. Siemens. In reply to Mr. Russell, he could only say that he found that when the electrodes were carefully polished, *his* results *did* agree within one per cent., and that he had found that time had no influence whatever on sparking distance. He did not think that closing the iron circuit in the cable transformer would be of any appreciable advantage, the induction was a little less just at the ends than elsewhere, but not enough to trouble about.

LEGAL INTELLIGENCE.

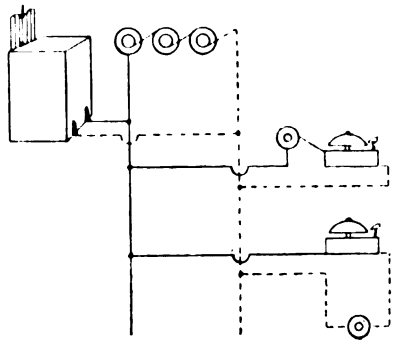
Lane Fox v. Kensington and Knightsbridge Electric Lighting Company (Limited).

FRIDAY, MARCH 4TH.

Mr. FINLAY, examining Sir FREDERICK BRAMWELL, said: If it were practicable, would there have been advantages in returns by "the earth"?—Yes; economy of material.

Mr. JUSTICE SMITH: Is that a very large expense?—It would be one-half the total expense of a system where there are two metallic conductors. You would save one-half if you ask me what is the expense of conductors. I believe I am right in saying that in this Company, the defendant Company, out of a total expenditure of about £135,000 to £140,000, some £35,000 to £40,000 represents the cost of the conductors out and home. In round numbers, therefore, it is a little under a third of the total expenditure. Then I ought to say that of that a certain portion is the conduit and a certain portion is the copper. The economy would be that you would do with one-half of the copper. I do not believe a return by soil to be practicable for electric lighting, having regard to the large number of amperes that have to be dealt with. Telegraphy, I think I am right in saying, may be measured by a very small fraction of an ampere; and in my own house, if I had all the lamps on at once, I should have about thirty-eight amperes passing through it.

Questioned on Clark's Specification, the WITNESS said: Clark's Specification has no drawing to it. Reading Clark's Specification I have drawn



this (F.J.B.1.). There is a primary battery of three cells. It is to be one of a constant current, that is to say, not one of the old batteries that used to go out of work in a few minutes, and that is to be coupled up at the same time to a Planté battery. The Planté battery is to make a wire so hot as will ignite a taper or a match—the primary battery is to charge the Planté battery and to ring bells. The two may be left in connection, and both batteries will serve to ring the bells. If a workman of intelligence acquainted with the subject were reading the Specification, he could carry out the plaintiff's directions, but I do not think the result would be successful.

Mr. FINLAY: The suggestion was made that that difficulty might be got over by increasing the size of the plates used in the secondary batteries.—I say it is commercially impossible because of the excessive cost, if for no other reason.

The ATTORNEY-GENERAL: I respectfully object to this. It has been ruled, as your Lordship is aware, that commercial cost is not the test of utility.

Mr. JUSTICE SMITH: Well, I cannot shut it out. Suppose it cost £100,000 and only brought in a guinea a year, I could not shut that out.

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The WITNESS: The cost of our batteries and their adjuncts was on the 31st December last £13,600, which again, in round figures, is 10 per cent. of our total capital. I as a shareholder should be very sorry to see that £13,000 increased to £65,000, which is five times as much. It would be loading the concern with an absolutely useless amount of capital. Whatever we think good enough for the outgoing conductor in the way of insulation that very same thing is applied to the return. The defendants have a system of feeders or feeding mains. Witness produced a map (issued as a Supplement with *The Electrician*, January 15th, 1892). The feeding mains are not shown, but the places where the feeding mains join on to the circuit mains are indicated by red dots. The feeding mains have no lamps upon them at all. The current reaches the point of delivery at the requisite voltage, the loss by resistance being taken up before there are any lamps to be supplied.

These feeding mains are adjusted in point of resistance to the length the electricity has to travel, so that, although the resistance varies as the length of the main, other things being equal, you get a uniform pressure in the generating station and a uniform delivery in the lamp circuit. That is to say, if it has further to go the sectional area will be larger, so that there is less resistance. There is a third kind of main, we have between the Kensington and the Queen's Gate Battery Station a pair of charging mains—I discriminate between lamp-circuit mains, feeder mains, and charging mains—there are no lamps upon those, of course. The Witness then went on to the bench and explained by the use of a model, the different methods of connection, the Attorney General standing by. The Witness then stated that the secondary batteries were employed by the defendants for the purpose of economising labour, and for the purpose of enabling them to work their steam engines with more efficiency. Having these batteries they could always give a load to an engine when working it. If the circuit did not want it the battery did.

Cross-examined by the ATTORNEY-GENERAL, Sir FREDERICK BRAMWELL was questioned at some length on the early use of secondary batteries, on Prof. Ayrton's curves, and on the system of feeders used at Kensington.

The ATTORNEY-GENERAL connected the two "earths" on fig. 5 of the Specification* by a pencil line, to represent an uninsulated conductor, and asked whether, supposing the secondary battery were put between the "n" and the earth, the position, from an electrical point of view, would not be exactly the same?—No; I should certainly say not, because then you would have the battery and the generator in series.

I will take it that you thought that the meaning of putting the secondary battery between the negative pole and the earth would be to make it in series?—I should have thought so.

Very well; I will take your answer. Now I wish to see if I can appreciate this distinction that you have taken. As I understand, the sole distinction that you draw between the position of the secondary battery in Lane Fox's patent and at Kensington is that you have it between the generator and the lamps?—No, that is not so. That is not my sole distinction, or anything bordering upon it. I hardly know how to separate position from connection.

Mr. JUSTICE SMITH: You say it would make no difference whether the battery was put immediately after the energy went out of the dynamos, or whether it was put at the other end of the line?—I think none, my lord, except upon the question of uniformity of distribution.

The ATTORNEY-GENERAL: is not the real object of putting it in between the generator and the lamps in order that you may get the opportunity of cutting in and cutting out cells for charging and discharging?—Yes, I should say that is the object.

The ATTORNEY-GENERAL set the model to show the dynamo developing 300 amperes, the two battery switches being at 50, and assumed that the dynamo gave 103 or 104 volts, and asked whether the arrangement was not that of Lane Fox pure and simple, and whether the batteries would not become charged until the potential rose to 103?—The WITNESS admitted, with certain qualifications, that this would be the case. He believed that one feeder would stand for hours at the same potential without any alteration during the time there was a small draught; but denied that, whatever the interval, whether one hour, if there were many lamps on, or two or three hours if there were few, the secondary batteries would be acting as regulators, because they would get precisely the same regulation from the engines if the batteries were not there.

If the engines ran at a constant speed, was it not known that the sudden putting on of more lamps either raised or lowered the voltage of the generator?—Yes; with certain generators, and unless corrected.

Now, I will assume that with such a dynamo you coupled up between the main and the earth secondary batteries of the voltage that you desired your lamps to be, do you follow me?—Yes.

And that you ran your generator at a constant rate of speed, having your secondary batteries in between the main and the earth. Would not those secondary batteries tend largely to correct the rise and fall of voltage when lamps were turned on and off?—I think they would.

Assuming the engine to be always running constant to that extent, would not the secondary batteries act as maintaining or tending to maintain a constant E.M.F. at the lamps?—Yes.

Assuming that at Kensington Court the discharge switch remains unaltered (the switch Y) for an hour, an hour and a half, or two hours, is not that exactly the effect that the secondary batteries have upon the pressure of the lamps if the engine maintains a constant speed?—Yes; I should think so, and if we did not also alter the field magnets.

I am not asking about other methods of correcting. I am putting a dynamo such as would be used in 1878.—There was in 1878 a mode of varying the intensity of the field magnet.

That is another method of correcting it, but assuming the field magnets to remain as they were at the time of the given running and not to be altered, would not the operation then be at Kensington Court exactly what I have suggested to you, namely, to keep constant the E.M.F. at the lamps?—I think so, but you only gave me one condition, which was the engine being maintained, and I wanted to point out that we had another mode, and did use it, of regulation.

That is a method of correcting it in another way.—Other than the speed being maintained.

I say it is a method of preventing or correcting the fall or rise of voltage in another way.—Yes.

SATURDAY, MARCH 5TH.

The cross-examination of Sir FREDERICK BRAMWELL by the ATTORNEY-GENERAL being continued, the witness thought that the absence of flicker or the maintenance of steady light was not largely due to the secondary batteries with steam-driven plant. Without the battery the thing would be perfectly uniform for all practical commercial purposes.

Mr. JUSTICE SMITH: Are you driving at the fact whether or not the application of the secondary batteries has a regulating effect or not?

The ATTORNEY-GENERAL: That the user of the secondary batteries, as and when they use them, my lord, most distinctly regulates these lamps, and keeps the pressure constant, as and when they use them.

Mr. JUSTICE SMITH: Go on. I do not think there is much doubt about that.

The ATTORNEY-GENERAL: I will not complicate it; your lordship knows the difficulty.

The WITNESS: If I were allowed, I might shorten the matter by saying that, in my opinion, you cannot have batteries constantly coupled up for the purpose of storage without at the same time there being, as an incident of their use, a certain amount of regulation. Whether needful or not I am not now saying.

Further questions were asked about the use of storage batteries in connection with gas engines, and about the meaning and use of the term "earth."

Mr. JUSTICE SMITH: Apart from the special verbiage of this specification, my mind is clear that it has been proved over and over again, and nobody disputes, in 1878 an engineer might have read it as being an A, B, or C return—I want no more on that. I have calculated it up, and I think we have spent more than one day on this word, the "earth." Sir Frederick has told me his view, and that is clear.

The ATTORNEY-GENERAL: Then I will not trouble one bit more on this. If your lordship will bear with me one minute I will call your attention to this. I ask you kindly to have in your mind, or note, the citation with reference to the sheath of iron wire: "This is overcome by using a sheath of the iron cable itself as the earth." I do not want to examine upon it, I only want your lordship to have that in your mind.

Now I ask you, was not the great problem in 1878 the distribution of the electric light?—Yes, I think so.

Was a Government inquiry held in the early months of 1879 with reference to the practicability of electric lighting?—Yes.

Were Prof. Tyndall, Sir William Siemens, Dr. Hopkinson, Mr. Deacon, Mr. Keates, Sir William Thomson, Mr. Conrad Cooke, Mr. Douglas, Mr. Stephenson, Mr. Preece, Mr. Burleigh, Mr. Woodall, and Mr. Lugg, examined before that Commission?—Well, I do not remember the whole of the names, but a large number of the best known names were—Sir William Siemens, Prof. Tyndall, Mr. Keates, Mr. Preece, and Mr. Deacon.

Can you tell me, was a single one of the eminent electricians who treated or described the distribution by subdivision of the electric current as being possible or practicable at that time—I put to you the spring of 1879?—I cannot tell you with certainty, but I can tell you that I believe the general opinion was that there was at that time no well-established well-known system of separation. I believe the investigation turned chiefly on arc lighting.

Had anybody to your knowledge, prior to the beginning of 1879, published—observe the word "published"—any practical system of distribution by multiple, parallel, luminous, incandescent, bridge—a multiple incandescent bridge?—I only use the word "parallel" in the sense that they go between the main and the return. I know of one with a sort of semi-incandescent lamp, which I believe was published before 1879. I think I know of two. Incandescent bridge pure and simple I do not recollect, but an arc not an arc lamp.

Before 1878 was not the Jablochkoff candle worked in series?—To my personal knowledge it was worked in series.

The Jablochkoff candle was the nearest approach to what I call subdivision that has ever been achieved prior to, we will say, Edison and Lane Fox's discoveries?—It does not so occur to me; I do not see it is anywhere nearer subdivision than anything else.

Were you acquainted with Mr. Lane Fox's practical work before 1878?—No.

He is talked of as a young man, and a man who knew nothing?—I wish I suffered under the same complaint.

Questioned about the use of earth returns, witness had no idea whether six yards square or six feet square would be sufficient for an earth plate to carry 50 amperes; he knew that uninsulated returns were used at the Leeds tramway.

After some questions about the arrangement of tinder boxes and electric bells in Clark's patent, the ATTORNEY-GENERAL asked: Now, with reference to known means in 1878 for distributing potential, with or without the aid of secondary batteries, can you point me out, or tell me—and I must say, can you produce to me—a single reference to Clark, or a development of Clark at any time prior to 1878, or subsequent, with the object of breaking up the current at a constant potential, distributing current at a constant potential?—No.

Have you ever considered Clark with reference to this problem till you were asked to advise your own Company in this defence?—I do not think so. I do not recollect it before.

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* *The Electrician*, Feb. 26, p. 438.

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Can you point to a single book, a text book, or elementary book, or even non-elementary book, right away up to the present day, which to Clark as an analogous use ——?

Mr. JUSTICE SMITH: Do not you think we have had enough of Clark?

The cross-examination was concluded by some questions about "feeders."

Re-examined by Mr. FINLAY, Sir FREDERICK BRAMWELL said that a current of 10 amperes returning by the soil would be of no practical value, since his own house took 38 amperes. He referred to the patents of Woodward in 1875 and Weidermann in 1878, which described parallel distribution. Asked whether there must be a tendency to regulate wherever secondary batteries were coupled up with the dynamo, witness said that wherever they were used for storage purposes, as an incident to that use there must be some tendency to regulate. But the regulation was not automatic, except in so far as it was an incident of the connection at any particular moment, that was automatic; but in so far as the practical regulation was concerned it was non-automatic, and he added that with a steam-driven plant one could work perfectly without the slightest fluctuation of any sort or description, if the batteries were put out together.

With reference to his answer in cross-examination that it would make no difference to Mr. Lane Fox's patent, pure and simple, if the battery were put on (Figure 5) immediately outside the dynamo, or where it was put, WITNESS wished to add that that would not be operating upon the mains by dotting batteries about the mains. It would be putting the battery in an improper place, because it would be close to another source of power, the dynamo being a source of power, and the battery being a storage of power. He would understand the storage would not be put close to the source.

Dr. JOHN HOPKINSON (examined by Mr. R. W. WALLACE), in reply to questions, pointed out that the lamps used by the defendants employed carbon *in vacuo*; but the lamp described in the patent was of platinum and iridium in nitrogen. These lamps were well known as laboratory instruments—they were never well known as articles of commercial use—in fact, they never had any commercial use.

Mr. JUSTICE SMITH: Is this on the point that you may have taken all the other inventions of Mr. Lane Fox and not infringed his patent as to the lamp—is that the point? There are many issues I have to decide, and I do not want to decide more than is necessary. This is disclaimed.

The ATTORNEY-GENERAL: I rely distinctly on the system of distribution. I say that is absolutely new, and that that is in the claim that is left.

Mr. JUSTICE SMITH: And you say that that system of distribution involves regulating, which you claim?

The ATTORNEY-GENERAL: Certainly, and I further say this, with regard to the lamp, the only question asked was with reference to the general character of the lamp, to show it was understood by Mr. Lane Fox in the system he was describing. I never claimed or suggested the defendants have taken our improved lamp. On the contrary, I admit at once the Edison carbon lamp is very much improved beyond that of Mr. Lane Fox, and was adopted by everybody. I have not asked a question on the lamp.

Questioned as to the term "earth," the WITNESS gave the following definition:—"The soil of the earth or anything electrically connected to earth which an electrician finds ready placed to his hand and uses as his second conductor, and so saves the expense of providing a special conductor *ad hoc*." I should say that on my definition the gas and water pipes would be "earth," or "the earth," but I find in Mr. Lane Fox's specification that he does not appear to use the term in so wide a signification as I should use it. I refer to page 4, line 20.

The WITNESS then referred to Noad's book, published in 1857, page 754, article 1,064, and to "Lardner's Handbook on Natural Philosophy," fourth thousand (1861), page 264.

Mr. WALLACE: Do you find there a similar use of the word "earth" and "the earth"?—Yes, it puts in this, "But it was afterwards discovered that the earth itself was the best and by far the cheapest, and most convenient, conductor that can be used for this return system of electricity."

Would it be a desirable thing for electricians if they could have used the earth as a return?—Yes, if the earth had played the same part with the heavy currents required for electric lighting.

Mr. JUSTICE SMITH: Now this is more important. Do you or do you not say that this return under Lane Fox could be worked by earth?—Only on a very small scale, a very small scale indeed. I should not like to fix the precise limits. I should not be afraid of working 10 amperes, but I should feel very uneasy in working 100. I think I might put it in that way. I would not say it could not be done. I say you could not go to 1,000. If you had 1,000 amperes that would generate oxygen gas enough on your earth-plate, if you used an ordinary, earth-plate to oxidise about 2lb. of iron per hour. Of course, that would be a rather serious matter with water pipes, as the oxidisation would be localised in particular places, and, independently of that, you would have great difficulties with the resistance that would be introduced—in fact, insuperable difficulties.

Mr. WALLACE: Would that be at all a practical means to use on such a system as the Kensington Court system?—No; certainly not.

Mr. JUSTICE SMITH: That is not the point, is it?

Mr. WALLACE: Well, on such a system as contemplated by this patent?

Mr. JUSTICE SMITH: Yes, that is the point.

Mr. WALLACE: Would earth returns be successful?—No, I think not.

Mr. JUSTICE SMITH: Tell me, do you know any electric lighting system in which they work earth returns in this country?—I think for a time Sir William Siemens worked it at Holyhead for arc lighting—a number of arc lights in series, and I suppose they would take perhaps 10 or 15 amperes through those, probably not more; and they discontinued it, I did hear, on account of the disturbance to the telegraphs. I have not seen that installation. Holyhead is a seaport, and they may have possibly taken the earth-plates down into the water; by "earth" I should have included the sea, of course.

Mr. WALLACE: In 1878 was or was not parallel distribution for electric lighting purposes known?—I should think it was familiar to any competent person that the work could be done in that way, or as soon as you had the proper lamp. I certainly knew it.

Mr. JUSTICE SMITH: You knew what in 1878?—That you could distribute electricity by a parallel system.

Mr. WALLACE: I will read you a passage from Kosloff's specification, which was published in 1875, No. 441: "The system of placing the lamps into the circuit may be effected in two ways, either by placing one series of lamps united by a metal wire in such a way," &c., &c. [*reading down to the words*] "the conductor at the other pole being in communication with the last lamp." Now, does not that describe working in series?—Yes.

Mr. JUSTICE SMITH: Where do you find that?—I think it is at the top of page 9, my lord.

Mr. WALLACE: "Or by subdividing the current, that is to say, the current at one pole is subdivided," &c., &c. [*reading down to the words*] "each lamp."—Yes.

What system of distribution does that describe?—Beyond all doubt, parallel.

WITNESS then referred to Woodward's patent 181,613, American specification 1875. Parallel distribution was described, but no claim was made for it. Jablochkoff, 3,839 of 1887, was also put as an example of parallel distribution; Leyden jars or condensers were used.

Mr. JUSTICE SMITH: There is nothing new in 100 volts?—No, no special merit in it, my lord. I use in my house 50. In these Courts there are about 85; and I think at Paddington they use 130.

MONDAY, MARCH 7TH.

The examination of Dr. J. HOPKINSON by Mr. R. W. WALLACE being resumed, the witness described experiments made at his own house with storage batteries. He always charged his batteries to a high point, not so much for the sake of potential in discharge as for the sake of the health of the battery.

Questioned as to the plateau, he said there were, in fact, two plateaux. There was a plateau which was not very flat in charging; there was a plateau which was much flatter in discharging. Those two plateaux differed very materially in their potentials. If he did not occasionally go up to 57 or 58 volts the cells would suffer. They would not last. Actually he made a practice of always being sure that they did get up to that once a week, and he thought they generally got up about twice a week to it. If he did not he would find the plates begin to buckle and get out of shape, bend, and come in contact with each other, and once they came into contact the battery was ruined. He did not find any direction to that effect in the specification.

Questioned as to the effect on the lamps of the high voltage used for charging, the witness gave the following figures:—

Volts.	C.-p.	Life.	Volts.	C.-p.	Life.
115	—	30	92	9½	—
105	—	310	80	4	—
100	16	1,000			

He did not think they ought to allow more than 2 per cent. variation from the mean. It ought to be kept well within that. If they had 101 volts on the battery they would get a very small current passing for a short time. That current would rapidly diminish and speedily become practically *nil*.

Mr. WALLACE: Assuming the batteries were taken away altogether, in your experience as an engineer what would be the effect on the constancy of pressure in the mains at Kensington Court?—Absolutely none. They work in that way at Gatti's installation in the Strand with a large station. There are scores of that kind of station in America—Edison stations.

In your opinion are batteries in such a situation as Kensington Court of any practical use for keeping constant the electromotive force except during the time they are solely used for replacing the engine and dynamo?—Quite so. In my opinion they are useless for regulation with the exception you named. Their use is to enable you to allow your workman to go at times when the demand is small.

Cross-examined by the ATTORNEY-GENERAL, Dr. HOPKINSON said that he had not made any prolonged personal observations as to the variations of voltage in Gatti's installation.

Questioned about the Select Committee of 1879, he said that there was at that time no incandescent lamp. He regarded it then as entirely a problem of how they were to deal with the arc lamp. He admitted that he had said, speaking of the platinum iridium lamp, "It ought with proper management to last an indefinite time." But he remembered afterwards that he went into some explanation as to the greater economy of the arc, owing to the higher temperature, and so on, there was then a difficulty as to the arc; he always held there would be no difficulties as to incandescent light.

Mr. JUSTICE SMITH: You know Sir Frederick Bramwell has told me the great question of the day in 1878 was this subdivision of the light.

The ATTORNEY-GENERAL: Yes, I have enough, my lord.

The model being placed at position D, the ATTORNEY-GENERAL suggested that the current began with both switches put at 56, and as the current increased they moved the discharging switch Y gradually from 56 towards 40. Was not the sole reason of moving the switch from 56 towards 40 because the batteries getting charged there would be too much pressure in the mains?—Yes. No amperes apparently were going into the boxes.

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To begin with, the switch X is put at 56, that is exactly opposite the switch Y the dynamo is delivering the amperes needed the lamps at 100 volts only, the current goes straight across, but as the object is to do what is done now, namely, to supply the lamps and recharge the batteries, the amperes in the battery are gradually increased. They begin at 100 and the pressure is gradually increased, involving the moving of the switch Y gradually from 56 towards 40 so as to preserve the pressure of 100 volts for the lamps. That is because, as the cells get charged, you get too much pressure for the lamps, and accordingly you move the discharging switch in accordance with the pressure of the total number of boxes, so as to procure the pressure of 100 volts for the lamps. Now, before it is moved from 56 to 55, the box 56 will be rising—we will put a hypothetical figure—it must be less—it must be about 1·8.—It would take less than half an hour or an hour, before it gets up to 1·8.

I assume during a quarter of an hour or half an hour the switch stands at 55.—No, less than that. Take it five minutes. Lamps are turned on and off in the circuit, and the secondary battery would not be acting during that five minutes exactly in the same way as Mr. Lane Fox describes, because during the whole time you are charging the battery. By the time you get to the 125 switch Y will be moved down to 46. To move it right away down that depends on the condition of the batteries at the beginning and the rate you are pouring electricity into them. The dynamo supplies not only the battery, but external work as well. The time occupied from switch Y getting from 56 to 40 depends on how many amperes are coming out of the battery—how much is wanted for the lamps.

Now I take the case before you move the switch at all, while the voltage is rising from what it was at starting, till it is necessary to move the switch from 56 to 55. Is not that working pure and simple as Lane Fox's during that period?—So far as Lane Fox there goes.

Yes, certainly?—Yes.

During that time WITNESS did not think that the existence of the secondary batteries in that position as being coupled up with the return wire regulated the pressure at the lamps to any sensible extent. If the steam engine was very bad and the man was very neglectful, then, no doubt, it would become more material; but with proper management it was absolutely unimportant and useless.

Would not the fact of those batteries being charged at that time in the way shown at D tend, when those lamps were suddenly turned on, to keep the electromotive force constant at the moment?—Yes, under those extreme conditions.

It is a question of extent. Would you be kind enough to turn them all to E, and then I shall not have to trouble you to go back again? "This assumes that more lamps have been put on, and that 300 amperes are needed in the circuit."—Yes.

"The dynamo A being competent to supply only 250, the balance of 50 has to come out of the battery."—Yes.

Now, I am going to point out to you presently that this is the second stage of Lane Fox.—Yes.

"Both switches X and Y are now at cell 45. The dynamo pressure is kept down to 100 volts as the 250 amperes from the dynamo goes straight across at 45 to the lamp circuit. As the battery discharges and the pressure would therefore fall, the switch Y is moved from 45 upwards towards 55, and as the 250 amperes are going direct from the dynamo to the lights, it follows that the switch X must at all times be on the same cell as switch Y." Now, I ask you whatever the number of cells be, keeping the switches X and Y opposite one another, and 50 amperes coming out of the batteries, and 250 from the engines, is not that a direct instance of the use of the second part of Lane Fox?—Yes; but he does not show how he gets from one stage to the other.

You will forgive me for not arguing the matter with you; I want to get my question answered. Now, Dr. Hopkinson, during that time if a theatre is turned on or if a fog comes on and a number of houses suddenly are turned on, would not the presence of the secondary batteries, coupled up as they are, discharging like that, tend to keep the electromotive force constant?—No, not to an appreciable extent—not in the latter case.

Would they tend to do it?—"Tend" when there is something else that governs it.

What is the other thing that governs it?—The man at the steam engine.

Then it does come to this ——?—That if the man at the steam engine fails you may get some benefit from that, if the man is away or anything of that kind.

Or if the personal error of the man with regard to quickness of observation and quickness of action is greater you get an advantage?—I cannot imagine any such excessive personal error as that.

Do not you know that into these questions of regularity personal equation does largely enter?—It does, no doubt; but then the degree of accuracy you require to get is so very much greater than what you will get from the battery.

Mr. JUSTICE SMITH: I may take it, apart from the question of the effective man, that D and E is Lane Fox pure and simple, with the current going from main to battery, and the other is E—*vice versâ*?—Yes; but the step from one to the other is where the difficulty comes in.

WITNESS was cross-examined at considerable length about the charge and discharge of secondary batteries, and on "earth." A sample of Andrews' concentric cable was handed to him, and extracts were read from a favourable report by the witness on this system. He believed that a very considerable number of largish installations had been insulated, or had been put up upon the Andrews system, and a good many ships.

Other examples having been referred to,

Mr. JUSTICE SMITH: What are we on now?

The ATTORNEY-GENERAL: We are on the question of what I may call the earth return being possible.

Mr. JUSTICE SMITH: I am aware of that; but in Dr. Hopkinson's view the earth return in a large place was impossible, on account of not being able to get sufficient connection with the earth. That would not apply to this at all.

The ATTORNEY-GENERAL: No, it would not apply.

Mr. JUSTICE SMITH: What has Andrews to do with it?

The ATTORNEY-GENERAL: I am not arguing, my lord, but I am going presently to point out to your lordship that this distinction between large and small insulations, which is set up by my learned friend, is no objection to this earth return.

Mr. JUSTICE SMITH: Because what?

The ATTORNEY-GENERAL: Because, supposing that it was a perfectly proper method of uninsulated return, that is to say, by earth——

Mr. JUSTICE SMITH: Do not put in "uninsulated"; say, "earth pure and simple."

The ATTORNEY-GENENERAL: Yes, I will take that—"pure and simple" for a moderate installation—say the one which Dr. Hopkinson suggested the other day. I do not want to cite the authorities now——

Mr. JUSTICE SMITH: I know that; but I want to see what bearing this has as to Andrews, only in order to see that I am following the point which Dr. Hopkinson takes, and which Sir Frederick Bramwell takes, and which is on the face of this case—that when you have an earth return pure and simple you cannot get a connection with the amount of amperes for the electric light; but if you put this, you have got the connection.

The ATTORNEY-GENERAL: Your lordship follows the point, and I will put it to him in two sentences. If there were a difficulty in getting proper earth, owing to the objections you take, would not a band of copper buried in the ground get over that difficulty?—Then you would have got your separate return.

Would not that get over the difficulty at once?—By making an earth connection?

Yes.—Of course it would. You have no earth connection for the purpose of conveying it.

You mean no soil connection?—Yes.

Was it not perfectly well known in 1878 that if your current was sufficiently large to make a difficulty in the size of your earth plate, an uninsulated conductor would do just as well?—I do not know that it was even known that there was a difficulty.

Do I understand you to say that the difficulty would not be apparent as soon as you came to an unwieldy size of earth plate?

Mr. JUSTICE SMITH: I think you may take it upon the evidence that supposing it read "the earth"——

The ATTORNEY-GENERAL: And that it means soil——

Mr. JUSTICE SMITH: Then you have to show a feasibility of working the earth.

The ATTORNEY-GENERAL: No, my lord; with very great deference I say not. I say, respectfully, you must be allowed to have all ordinary electrical equivalents.

Mr. JUSTICE SMITH: That would depend upon whether the specification excludes the others.

The ATTORNEY-GENERAL: Certainly.

Mr. JUSTICE SMITH: I say that is the point.

The ATTORNEY-GENERAL: If the language of the specification is soil, and soil will do for a small one——

Mr. JUSTICE SMITH: There is an end of the case.

The ATTORNEY-GENERAL: Then I say the ordinary electrical equivalents are not only allowed, but must be allowed to be included to deal with the question of a large installation. I cannot argue it now, as your lordship is aware.

WITNESS was cross examined on his patent for the three-wire system, in which it is suggested that the middle conductor need not be insulated. He thought that the word "condenser" in Mr. Lane Fox's letter to *The Times* referred to Leyden jars. He did not think that secondary batteries was a warrantable extension of the meaning.

Dr. HOPKINSON was briefly re-examined by Sir HORACE DAVEY.

Mr. R. E. B. CROMPTON, examined by Sir HORACE DAVEY, said that he had been connected with electrical engineering since the year 1878. He commenced carrying out his first contract in the year 1878. At that time he took to the new profession of electric light engineering. There was nobody in the business, with the exception of Messrs. Siemens and Mr. Wilde of Manchester. He designed the installation at Kensington as an engineer, and carried it out as a contractor in 1886. He took the contract for putting up the electric light in these Courts at the end of 1881 or the beginning of 1882. It was the first large installation of incandescent lighting in England. There were 33 cells, three in parallel. At first, compound dynamos were used. On one occasion the batteries were turned on to three lamps. They burned very brilliantly, and one burst. They then turned on the whole of the lights in the Court, and found that they were all equally brilliant, and would have been quickly destroyed, so they immediately switched them off again. The end connection was altered to the 32nd or 31st cell. For a short time the lamps were about the right brilliancy, but in a few minutes the lamps were again too bright. The next day he tried the experiment of switching on the secondary batteries alone, without the assistance of the dynamos. He then was surprised to find that the lamps were not bright enough—in fact, so dull that the Court was only half lighted. The ultimate fate of the accumulators was that Her Majesty's Office of Works ordered them to be removed and their place to be taken by additional dynamos. He met Mr. Lane Fox within two or three months of the trouble, and he asked him how he accounted for this tremendous change in the pressure which they had observed between the times when the dynamos were parallel to the batteries and the times when the batteries were working alone. He told witness that he attributed it to the cells being bad; he did not say anything about fitting switching apparatus. Two years later he put a battery into his own house. He was attempting to improve accumulators—to get over these difficulties—among others the difficulties of pressure which gave this trouble in the Law Courts. He found out after he had had the battery in his own house that it was

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impossible—that this difference of pressure was inherent to the lead couple battery, that is the Planté battery or any of the modifications that had been brought out. He found that it could be only mitigated very slightly by increasing the active service of the plates in contact with the electrolyte, and he at once accepted the fact and devised proper switches for switching cells in and out.

The witness then described the construction and details of the Crompton Howell battery, and put in some tests and curves showing the results of an attempt to charge with pressure never exceeding 1 per cent. above the 100 normal. He began with it at 2·14, and then raised the pressure so that it came to 2·160, and a current of 3 amperes commenced to flow. They kept it steady for an hour and fifty minutes. At the end of that time a peculiar action, called "sulphation" of the cell, took place. After 12 hours and 20 minutes they had only got 3 ampere hours into that cell. Only the hundredth part of the capacity into that cell. The object of this test was to see whether they really could get any practicable charge into the battery at all, according to Prof. Perry's proposal. After raising the pressure to 5 per cent., they got altogether 32 ampere hours in 24 hours, so that it would take ten days to charge the battery. The object of the second experiment was to show clearly that this slow charge not only did not fill up a cell, but also exercised a very hurtful effect. When they first commenced, having raised the potential as near as possible 1 per cent., they found 2·243 amperes were entering the cell; twenty minutes later they found that that had fallen to 1·1 amperes. It fell so rapidly that in the first twenty minutes it had halved itself. Ten hours thirty minutes later it had balanced itself so completely that practically no current entered the cell. This experiment was done about six days ago, about two days after Prof. Perry had given his evidence. There was no discharge practically. The cell ran down immediately, with only eleven ampere hours. It had got so sulphated that the whole of its charge had passed away, due to the treatment it had received. He had noticed it always at ending these attempts to make cells do what Mr. Lane Fox wished them to do, that is to say, to float—sometimes discharging a little, sometimes charging a little, and it accounted for the whole of the failures. In five minutes there were 14 amperes discharged. They commenced at the rate of 14 amperes, and they put it up to 20 as quickly as they could, which was the proper discharging rate of the cell—a very low discharging rate for that size of cell—and in thirty-five minutes it had run down practically. The third experiment was an endeavour to charge the battery in 18 hours, being the outside time which could be claimed in the use of batteries on the Lane Fox system.

TUESDAY, MARCH 8TH.

Mr. CROMPTON, recalled and examined in chief by Sir HORACE DAVEY, said he knew of two mechanical means of counteracting the practical difficulty from the rise and fall of the pressure in the charging and discharging other than the arrangement employed at Kensington. They were exact equivalents of it. They might cut off cells, introduce resistance, or introduce a counter electromotive force. There was no hint or suggestion of anything of that kind in the specification. No competent electrician would introduce the means described into Mr. Lane Fox's system without the application of experiment, trial, and ingenuity. It took witness up to 1883 or 1884 before they suggested themselves to either Prof. Perry or himself, or others experimenting in that direction. They could mitigate or diminish, but could not neutralise the rise and fall altogether by any increase in the conducting surface At Notting Hill Gate Station the batteries were five times the size, and they had practically the same rise and fall as at Kensington. The batteries in the Kensington Station never alternately charged and discharged without the use of a switch in the manner which it was suggested Lane Fox's was intended to operate. The first process was charging the main and accumulators up to a pressure of 140 volts. When both switches were at 50, and lights were put on the circuit, the boy, seeing the voltmeter moving down, would sign with his hand, and the engineer would go as fast as he could go; and if he saw the voltmeter not going up rapidly he would run to the sliding switch and raise it as rapidly as he could, turning on several cells. That was in practice the way they met the drop occasioned by the putting on of a load of lamps, *i.e.*, by speeding up the engine at once. After 10 to 12 p.m. they left the battery to act alone. Directly they stopped the engine cells were switched up to 49 say, and a few minutes afterwards to 50, and a few minutes afterwards to 51, and then they would leave it for the night. He tried using the earth, in the sense of the soil, as a return conductor for the purpose of completing the circuit several times. In the year 1879 or 1880 he had a portable electric lighting plant at Henley Regatta, and he thought it a very good opportunity of getting an earth return. They had lights on the Henley Bridge. He took sufficient insulated wire to make only one conductor, and he took a quantity of uninsulated wire for the other conductor. In the first instance he put a coil of the uninsulated wire into the water close by his engine in the River Thames, and connected one pole of the dynamo with it, and connected the corresponding pole of the lamp with another coil of wire, which he threw into the river at Henley Bridge, so that it rested on the bottom of the river. The result was that he could get absolutely no current through the dynamo.

Mr. JUSTICE SMITH: Do you say the earth is not a conductor at all?—I say the water of the River Thames, which is very pure, was practically a non-conductor.

The current was 20 amperes. With a current of 20 amperes they got nothing back to the dynamo. The resistance was so high they got practically nothing. He tested the resistance. On the second test he found the resistance was 10 ohms. He tried at Stanton Ironworks the second class of return by water, complete water pipes, and had great difficulty in getting what he desired. He had used earth in the second sense of a continuous metallic conductor bedded in the earth frequently—the Southend Tramway, for example. In the early stages of the use of his special system of mains he did not strain them sufficiently, and some of the conductors touched the earth at various points. The effect of the current passing by that means to conductors covered with lead was that such leakage as occurred in the house found its way to earth by the outside covering of these conductors; and it was remarkable how quickly the lead was eaten away whenever there was a leakage in the house. They noticed that the corrosion was always confined to the points where there was a change of state, where the pipe passed from a wet place into a dry place—it was entirely confined to the wet place. His general observation was where they had put an outside conductor, not the secondary conductor, but the outside conductor, actually to earth, it had been corroded with extreme rapidity; a few days sufficed to cut it in two. They did not dot their secondary batteries about the mains, as proposed by Mr. Lane Fox, to overcome the resistance at particular points.

Or anything like that way?—Nothing like that way.

Or for that object?—Or for that object; we do the reverse in fact.

And do you use other means for obtaining that object?—Yes.

Those other means being what?—The feeders and pilot wires.

Cross-examined by the ATTORNEY-GENERAL, WITNESS stated that by feeder he meant a wire which took current some point away from the engine-room, which feeder wire was not tapped by lamps till the required point. A pilot wire was a return tell-tale to tell the people in the engine-room whether the voltage had fallen from any cause. It told what the pressure was at the point it came from. Those were the two improvements which were necessitated to a large extent by the size of his system although used in quite small systems.

Now, I put it to you, and I ask you to answer my question without indulging in theory for the moment. Do not the presence of secondary batteries and cells remaining constant at any given position tend to diminish that flicker?—I say, advisedly, they do not. He was examined before the Board of Trade in 1889. The Kensington installation, as it was now used, practically was then in force, but not on as large a scale. They did not have a separate charging dynamo at that time.

Now I want to read three questions and answers, No. 4,516. Evidence given when you were examined on the 10th of April, 1889, by my learned friend, Mr. Moulton: "In your case I believe you use only a small allowance of batteries, because you use them only as regulators, and just for the period of maximum and minimum supply, is not that so? —(*A.*) That is so, yes"?—Yes.

There are three things put to you there, as regulators, and for the period of maximum and minimum supply. Now I ask you, Mr. Crompton, kindly to think carefully, did you not mean, when you gave that answer, you were using the secondary batteries as a fly-wheel or regulator to control the electromotive force?—Not as a fly-wheel or regulator. We use them as reservoirs.

Mr. JUSTICE SMITH: But, my dear sir, look at the question.

The ATTORNEY-GENERAL: Did you not mean then that you used them as a regulation to control the electromotive force?—You said a fly-wheel - not as a fly-wheel—as a regulator for long changes.

As a regulator to control the electromotive force?—As a regulator for long changes.

Is not the only reason why you never want to shift the switch higher than 45 on the discharge because the potential of total number of cells falls below the requisite pressure?—That is the reason, as it falls you shift the switch so as to increase the number of cells.

You put on extra cells to keep up the potential?—Yes.

The fall in the potential is due to the draught current coming out of it is it not?—Yes, it is due to two things.

After reading extracts from Mr. Dobson's remarks during the discussion on Mr. Crompton's Civil Engineer Paper, the ATTORNEY-GENERAL said: You told my lord in chief that you rely on the boy signalling to the man, and the stop-valve being altered. Now I ask you this, whether, when the steam escapes and the steam-valves cannot be altered, these accumulators are not here pointed out as acting as regulators?—Not without the switches. He falls on his second line of defence—his switches –and then proceeds to switch up, and his switch-board is so placed that he can do it.

WITNESS was next cross-examined on his Paper read before the Society of Telegraph Engineers and Electricians.

Questioned as to the charging experiments, WITNESS said he had made the same experiments and repeated them half a dozen times in the last ten years.

Mr. JUSTICE SMITH: How many times, did you say?—I have made the same class of experiments, not exactly on the same lines but with generally the same results, during the last ten years.

In further cross-examination WITNESS said switches such as were necessary for batteries were not known in 1880. His firm might have sold multiple switches at that date. It was a distinct invention using two switches. To detach the charging switch from the discharging switch was an invention. After being questioned as to the Law Courts installation, his opposition to Mr. Lane Fox's disclaimer, and the part he took in the discussion on Mr. Lane Fox's Paper, read before the Society of Telegraph Engineers in 1881, the WITNESS was re-examined by Sir HORACE DAVEY, and the Court adjourned until Monday, 14th inst.

Sir Henry Mance was briefly examined and cross-examined on "earth" on Monday. The Judge stopped further questions, saying that it seemed to him that "the earth" means any return, but is liable to be altered by the context in which it is used. Mr. H. W. Miller, resident engineer at Kensington Court, gave evidence about the details of working, and was cross-examined by Mr. Moulton. Mr. R. S. Erskine, the secretary, was briefly examined by Mr. Wallace, and cross-examined by Mr. Moulton. Mr. Swinburne followed, and brought out one or two new points, introducing the suggestion that Mr. Lane Fox wished to avoid the fall of pressure due

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to the resistance of the mains by the use of an earth return of small resistance. He had calculated that an earth-plate to take 1,000 amperes would be somewhere between 25 acres and 4 square miles, with one volt at each plate, and that if gas and water pipes were used, about 10 tons of metal would be eaten away in a year.—His cross-examination was continued on Tuesday morning. Mr. Shillitoe, electrician at Hatfield House, gave evidence on the practical use of earth returns; and Mr. Dorner, of Messrs. Siemens Bros., described an attempt to make return by the earth at Lord Armstrong's house at Craigside in 1878. Prof. Kennedy was examined by Mr. Wallace, and described the use of secondary batteries by the Westminster Company. He denied that the battery would sensibly counteract flickering. Mr. B. Drake gave evidence about the use of storage batteries, and was followed by Mr. F. King.—On Wednesday, Mr. King's cross-examination was concluded, and after a short discussion it was agreed that rebutting evidence would not be brought by the plaintiff. Mr. Finlay then made a speech; and it was arranged that the Attorney-General would address the Court to-day (Friday).—The abstract of the report will be concluded in our next issue.

The National Telegraph Works Company (Limited).

The action of Hedges *v.* the National Telegraph Works Company (Limited), of Wainwright-street, Aston, Birmingham (J. Slater Lewis, Manager) came before Mr. Justice North, in the Chancery Division, on Friday last. The action was brought by the plaintiff, on behalf of himself and all the other debenture holders in the Company, for the appointment of a receiver of the property of the Company. The plaintiff was the holder of six debentures of £25 each. Since the notice of motion in this action had been given the Company had passed a resolution to wind up voluntarily. The principal of the debentures had now become payable.

Mr. DRUCE appeared for the plaintiff, and the Company did not oppose.

Mr. Justice NORTH appointed as receiver a gentleman named.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March* 4, 1892.

Long-Distance Transmission of Power.—The long-distance transmission of power in its various phases is now occupying the attention of electrical engineers and capitalists more than at any previous time since the electrical industries came prominently before the public. A number of new problems have been presented in the construction of plants of this character, especially in the far West in the mountainous regions of Colorado and Nevada. It has been found that one of the most difficult features of the work is the construction of a sufficiently durable line, as the obstacles to be overcome are much greater than those met with in any other class of electrical line construction. In the plant at Telluride, Colorado, using Westinghouse alternate-current motors, the power is furnished by a 600ft. waterfall 8½ miles from the line. The construction of the line necessitated an expenditure of $10,000. The generating plant was 9,000ft. above the sea, while the elevation of the motor plant at the mine was 12,000ft. A "hog back" between the two required the carrying of the line to an elevation of 1,400ft. over a single peak. The entire line was inaccessible for nine months in the year, and it was necessary to construct it in the most durable manner possible. Ordinary glass insulators were used; and although the E.M.F. on the line is 3,000 volts, no trouble from defective insulation has been experienced. For a part of the distance it was necessary to carry the line through the densest timber, while at other places projecting rocks and crags had to be blasted out to afford a passage way for the line, which is of No. 5 bare copper wire. The poles for the lines were cut within 100 to 200ft. of the route, but in at least half of the construction it was necessary to blast the holes in which the poles were set.

BOOKS, &c., RECEIVED.

"Taschenbuch für Monteure elektrischer Beleuchtungsanlagen," by S. Freiherr S. Gaisberg. (Munchen and Leipzig: R. Oldenbourg.)

"Secondary Batteries." By J. T. Niblett. (London: Biggs and Co.)

"Year-Book of Science." Edited, for 1891, by Prof. T. G. Bonney, F.R.S. (London: Cassell and Company, Limited.) Price 7s. 6d.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.

The tenth annual edition of the above well-known annual is now ready, price 7s. 6d.; post free, in the United Kingdom, 8s. 3d; abroad (with the exception of a few countries), post free, 8s. 10d.

The edition consists of between 900 and 1,000 pages, and special care has been taken to make the Directorial division of the book, which has been considerably extended, thoroughly accurate and reliable. In this respect no possible comparison can be made with any similar publication.

To the Handbook division has been added several features which will be found of service to the Electrical and Allied Trades. The Digest of the Law of Electric Lighting has been thoroughly revised and brought up to date, and the most recent Board of Trade Regulations are also included. The various tables and tabulated statements have been remodelled and amplified; and a new feature is the tabulation of valuable information respecting Electrical Limited Liability Concerns.

An important feature is the space devoted to the officials of Foreign and Colonial Governments who have the superintendence of contracts and the giving of orders for electrical plant and apparatus; and as this has been kindly supplied by the various Government departments, it can be relied upon, as can also the particulars given respecting the Home Government departments.

The profession will find "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK a trustworthy work of reference, and purchasers of plant and apparatus may confidently turn to its pages for the names of all the principal firms supplying their requirements. Nearly every firm of any standing in the Electrical and Allied Trades is represented in its advertisement pages.

A digest of the contents of the book will be sent on application.

TENDERS INVITED.—The Committee of the Railway Clearing House are prepared to receive tenders for wiring and fittings for lighting the two blocks of buildings situate in Seymour-street, Euston-square, London, known as the Railway Clearing House. Specifications, schedules and plans may be had, on payment of 21s., from Mr. H. Smart, Secretary to the Committee. Tenders must be sent in by eleven o'clock on Wednesday, the 30th instant. Further particulars will be found in our advertisement columns.

——— The Committee of the Glasgow Town Council on Gas Supply and Electric Lighting invite tenders for providing and erecting engines, dynamos, &c., at their Central Electric Lighting Station, Waterloo-street. Plans and specifications may be seen, and forms of tender obtained, on application to Prof. A. B. W. Kennedy, 19, Little Queen-street, Westminster, S.W., or at the Gas Office, 45, John-street, Glasgow. Tenders must be sent in by the 29th inst., to Mr. J. D. Marwick, Town Clerk, City Chambers, George-square, Glasgow. Further particulars will be found in our advertisement columns.

——— The Bristol Urban Sanitary Authority invite tenders for various works for the central station at Temple Back. Plans and sections may be seen at the offices of Mr. Henry Williams, 21, Clare-street, Bristol. Copies of specifications and forms of tender may be seen and obtained at the offices of the Sanitary Authority, on and after Friday, March 25th. Tenders must be delivered at the offices of the Sanitary Authority, 51, Prince-street, Bristol, by Friday, April 8. Further particulars will be found in our advertisement columns.

APPOINTMENT VACANT.—The Corporation of the City of Londonderry require the services of a competent electrical engineer to advise on the electric lighting of the City. Applications, with copies of testimonials, &c., must be sent in, on or before the 30th instant, to Mr. R. N. Chambers, Town Clerk, The Guildhall, Londonderry,

SALE BY AUCTION.—Mr. Geo. N. Dixon will hold an important sale of contractor's plant at Fallowfield, near Manchester, on Wednesday, the 30th inst., and following day. Amongst other things a complete Gülcher electric lighting plant will be offered for sale.

MESSRS. NALDER BROS.' CATALOGUES.—We have received two price lists recently issued by this firm, the one of electrical and other similar instruments, and another of ammeters, voltmeters, and resistance frames. These lists illustrate many of the most recent and improved forms of galvanometers, keys, resistance boxes, electrometers, and other testing and measuring instruments. Hardly any old-fashioned patterns are included, and the illustrations show all the prominent details clearly. The typography of this catalogue is very excellent.

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REMOVAL NOTICE.—Messrs. Dorman and Smith announce that they have now removed into their new premises at Ordsal Station Electrical Works, Salford, Manchester, where all communications and goods are to be forwarded: the above is the only address of the firm. Messrs. Dorman and Smith are manufacturers of all kinds of electric light accessories.

THE METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—This Company announce that the engineer's offices are removed from 4, Waterloo-place, S.W., to premises adjoining the Manchester-square Station, and that on and after March 18th all communications should be addressed to 17, South-street, Manchester-square, London, W.

MACMAHON'S PATENT ELECTRIC CHECK SYSTEM (LIMITED).—Mr. P. T. Travers. of 27, Albemarle-street, W., has been appointed liquidator in the voluntary winding-up of the above Company.

INSTITUTE OF MEDICAL ELECTRICITY (LIMITED), (IN LIQUIDATION). Mr. J. W. Biggs, of 12, Delahay-street, S.W., announces the first and final dividend of 7s. 11¼d. in the £ in this matter.

ISLE OF MAN INTERNATIONAL EXHIBITION, 1892.—Mr. George North, M.I.M.E., of 90, Queen-street, London, E.C., has been appointed representative for London and the South of England for the above Exhibition, which will be opened on July 4th next.

MESSRS. W. H. ALLEN AND CO.—The ss. "Ophir" has been fitted with 850 sixteen candle-power lamps, together with arc lights for the Suez Canal. The engines and dynamos are both of Messrs. Allen and Co.'s make, and consist of four sets of compound twin engines of 40 H.P., driving direct a compound-wound dynamo with drum armature. The work was carried out in four months from date of order.

CRYSTAL PALACE ELECTRICAL EXHIBITION.—Additional pages relating to the exhibits at the Crystal Palace have recently been added to the catalogue, and will be found useful to visitors. These pages are called "A Guide to the Crystal Palace Exhibits"; but although several useful exhibits of electrical publications are included in the Exhibition, no reference is made in the Guide to the position of the stands. So far as *The Electrician* Company's stand is concerned, we have pleasure in supplying the omission by notifying our readers that they can obtain electrical publications at Stand No. 43A, near the High Level Entrance.

BLOCKLEY ELECTRIC LIGHTING AND MANUFACTURING COMPANY (LIMITED).—We learn that the contract for the erection of lightning conductors for Winchester Cathedral has been entrusted to this firm.

ERNEST SCOTT AND MOUNTAIN (LIMITED).—This firm send us a copy of their Engineering Catalogue, which includes triple-expansion engines for mills, gun-boats, launch engines, Admiralty and pattern feed, fire, and bilge pumps, air and circulating pumps, workshop engines and condensers, forced draught fans, hydraulic pumps, and illustrations of the larger class of gun-metal and brass castings which their foundry is capable of producing.

THE NEW TELEPHONE COMPANY (LIMITED).—A circular is issued under the auspices of the Directors of the Pioneer Telephone Company, announcing that the new Telephone Company will shortly commence operations, and promising telephone users "subscriptions at little more than half those now charged in London." The new Company's system "is to have twin wires, and to be fitted with the newest switching apparatus."

RUBBER.—Rubber receipts at Para during January are reported to have been 3,030 tons, an amount much in excess of the usual receipts.

THE POOLITE MUSICAL SOCIETY.—The first smoking concert was given by the above Society in the dining saloon, Broad-street Station, on Tuesday evening, the 8th inst., when about 200 of the *employés* and friends of Messrs. Poole and White (Limited), (of Bread-street, City, and King's-road, Camden Town) assembled. A first-class programme had been arranged, and was successfully carried out.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

February 18, 1892.

3,145. J. WHITEHEAD. Birmingham. Improvements in electric globe and shade holders.

3,161. J. H. AHRENS. London. Indicator of railway stations by electricity.

3,211. F. BROWN. London. An improved electric switch.

3,212. F. BROWN and P. COLLINS. London. Improvements in the application of electric light to roundabouts, and the like, which improvements are also applicable to advertising purposes.

February 19, 1892.

3,223. G. WILSON. Sheffield. Improvements in apparatus for electrically signalling the engine-drivers or the guards of trains.

3,233. W. S. RAWSON, C. S. SNELL, and WOODHOUSE AND RAWSON, UNITED (LIMITED). London. Improvements in apparatus to be used in connection with electrically driven machines.

3,234. C. S. SNELL, and WOODHOUSE AND RAWSON, UNITED (LIMITED). London. Improvements in electrical switches suitable for use in connection with electric launches and the like.

3,240. J. LANG. London. Improvements in materials or compounds to be used in the manufacture of moulded articles, such as door handles, insulators for electrical purposes, boxes, toys and other articles of the like kind.

3,244. W. MITCHELL. London. Improvements in the method of and apparatus for lighting by electricity circular switchback railways.

3,283. J. H. TONGE, L. CLARK, and MUIRHEAD AND COMPANY (LIMITED). London. Improvements in electric arc lamps, specially applicable to search lights.

3,291. E. PAYNE. London. Improvements in tubular electrical conductors.

3,297. C. VOGT. London. Improvements in electric meters.

3,300. C. J. BARLEY. London. Improved means for effecting the connection of electrical conductors.

February 20, 1892.

3,314. C. B. BURDON. Hornsey. Improvements in and relating to the utilisation of alternating currents of electricity for producing motive power, for charging storage batteries, and for other electro-mechanical and electro-chemical operations.

3,366. T. L. HEMMING. Birmingham. Improvements in dynamo-electric machines.

3,379. W. R. RENSHAW. London. Improvements in stoves applicable especially to thermo-electric stoves.

February 22, 1892.

3,423. Sir C. S. FORBES, Bart. London. Improvements in telephones.

3,427. C. A. J. H. SCHRODER and H. E. R. SCHRODER. London. A new carbon electrode for electric arc lighting, to be called the "electric torch."

3,443. G. HUGHES. London. Improvements in electrie arc lamps. (C. H. O. Japy and O. Helmer, France.

February 23, 1892.

3,472. R. J. BOTT. London. Improvements relating to incandescent lampholders.

3,488. A. C. HAMILTON. London. An improved method of coiling-up conductors of portable electric lamps.

3,513. G. D. DAVIS. London. Improvements in diaphragms for electrical cells.

3,514. G. D. DAVIS. London. Improvements in the process of electrolysing alkaline salts.

3,521. O. IMRAY. London. Petroleum lamp with electrical igniting device. (C. Wasmuth, Germany).

3,522. O. IMRAY. London. Improvements in electrical igniting devices for gas lamps. (C. Wasmuth, Germany).

3,523. O. IMRAY. London. Improved galvanic element. (C. Wasmuth, Germany).

3,538. R. J. CHARLETON and H. WALKER. London. Improvements in distributing and controlling electric currents in mines or other dangerous places.

3,542. H. H. LAKE. London. Improvements in telephone apparatus. (W. Gray, United States).

3,559. S. W. KIMBLE. London. Improvements in the manufacture of compositions for insulating or other purposes.

3,560. S. W. KIMBLE. London. Improvements in trolly-wire hangers and other appliances for use in overhead electric railway systems.

3,561. S. W. KIMBLE. London. Improvements in trolly wheels for electrically propelled vehicles.

3,562. S. W. KIMBLE. London. Improvements in the construction and mounting of electrical connecting devices upon their non-conducting supports.

3,569. A. CAY, trading as J. STEVENS AND SON, and also as STONE, FAWDRY AND STONE. London. Improvements in the glass chimneys, globes, and shades of electric and other lamps.

3,572. A. F. LAW. London. Improvements in apparatus for electrically operating or controlling type-writing machines, type-setting machines, or apparatus for recording, indicating, or signalling. (E. F. Law, Russia).

February 24, 1892.

3,595. F. MOORE. Birmingham. Improvements in shades and reflectors for incandescent electric lamps.

3,631. F. BIDTEL. London. Improvements in the manufacture of compound and insulated wires.

February 25, 1892.

3,654. E. RICHTER. Manchester. Improvements in electric burglar alarms.

3,707 J. C. MEWBURN. London. Improvements in electric arc lamps (P. Sée, France).

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3,714. D. MacPherson. London. Improvements in safety switch frogs.
3,719. A. B. Burnand. London. Improvements in apparatus or switches for controlling electric currents.
3,724. H. W. Sander and M. D. Memmell. London. An improved electric arc lamp.

February 26, 1892.

3,750. Sir C. S. Forbes, Bart. London. Improvements in microphones and in apparatus connected therewith.
3,758. W. F. Parkinson. Newport. Improved holder for incandescent electric lamps.
3,801. L. W. Winnall and W. H. Winnall. London. Improvements in electric bells.

February 27, 1892.

3,873. H. C. Donovan. London. Improved insulating media for electrical conductors.
3,875. C. Coerper. London. Improvements in and relating to electric motors.
3,881. K. Kahabka. London. Improvements in electrical accumulators.

February 29, 1892.

3,887 F. E. Stuart. Twickenham. A system of sending and receiving signals on telephone lines for use in fire brigades and other purposes.
3,919. W. S. Rawson and Woodhouse and Rawson United, Limited. London. Improved method of preparing incandescent lamps.

March 1, 1892.

3,951. J. S. Lewis. Ealing. An improved telephonic transmitter diaphragm.
3,970. B. J. B. Mills. London. Electro-magnetic machines. (R. Lundell. United States.)
3,971. B. J. B. Mills. London. Improvements in power-transmitting devices, especially applicable to the electrical propulsion of vehicles. (E. H. Johnson, United States.)
3,991. G. H. Nunn. Manchester. Improvements in electrical call and indicating apparatus.
3,996. W. P. Thompson. Liverpool. Improvements in galvanic electric adhesive plasters. (J. W. Shults, United States.)
3,997. C. H. Smeeton and H. Page. London. Improvements in reflectors for electric lamps.
4,003. W. S. Rawson, W. P. Gallwey, and Woodhouse and Rawson, United, Limited. London. Improvements in electro-magnetic tools.
4,010. W. C. Lockwood. London. Improvements in telephones.
4,015. H. H. Lake. London. Improvements in electrical devices for stopping and starting horses. (The Holson Electric Harness and Supply Company, United States.)
4,017. H. H. Lake. London. Improvements in electric measuring instruments. (E. Weston, United States.)
4,025. W. H. Miller. London. An improved means of effecting electrical communication through the medium of a clock or similar apparatus.

March 2, 1892.

4,068. J. B. S. Booth and E. J. Falconer. Manchester. Improvements in telephones.
4,097. E. C. Russell. London. An improvement in the construction of electric arc lamps.
4,103. R. Goodwin. Dublin. Electro-deposition of aluminium on metals.
4,111. J. M. Glover. London. An improvement in electro-magnetic time and date-stamping machines.
4,112. J. M. Glover. London. An improvement in electro-magnetic postal, cancelling, time and date-stamping machine.
4,113. J. M. Glover. London. Improvements in electro-magnetic time and date stamps.
4,125. F. T. Hollins. Leytonstone. Improvements in electrical circuit arrangements and apparatus for telegraph message signalling.
4,134. C. E. Kelway. London. Improvements in electrical visual signalling apparatus.
4,152. W. J. Herdman. London. Improvements in electro-therapeutic apparatus.
4,154. E. Viarengo. London. Improvements in electric batteries.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

4,479. Morgan-Grenville. Electrical conductors.
4,881. Clark. (Sigmund Schuckert and Company). Electric tramways.
5,461. Dickinson. Electric traction.
5,715 Pitt (Davidson). Insulating electrical conductors.
6,029. Walenn and Timmis. Electro-depositing copper, &c.
6,030. Walenn and Timmis. Electro-depositing copper, &c.
6,318. Mitchell. Medico-electric batteries.
6,492. Barter. Electric glow lamps.
17,310. Von Orth and Breslauer. Electric signalling.
19,370. Dunand. Incandescent electric lamps.

1892.

278. White and Allam. Electrical conductors.
645. Gendron. Electric welding.
798. Siemens Bros. and Co., Limited (Siemens and Halske). Electrical conductors.

COMPANIES' MEETINGS & REPORTS.

Direct Spanish Telegraph Company (Limited).

The following is the report and accounts of the Directors of this Company for the half-year ended 31st December last, to be presented at the general meeting of shareholders, to be held on Tuesday next, the 22nd inst., at Winchester House, E.C., at 12 o'clock.

The accounts for the half-year ended 31st December show, after providing for debenture interest, a balance to the credit of profit and loss of £5,028. 12s. 11d.

The traffic receipts show a decrease of £2,214. 4s. 9d. as compared with those for the corresponding period of 1890. The falling off in the receipts is chiefly due to the reductions of rates which the Company had to submit to at the International Telegraph Conference held at Paris in 1890, and which came into force on the 1st of July last.

The working expenses are £17. 4s. 5d. in excess of those for the corresponding period of last year.

The Company's cables, and the land-lines in connection with them, have with one exception continued in good working order throughout the half-year; a serious fault having suddenly developed, on the 23rd of October, in the Falmouth-Bilbao cable. The cable was repaired by the Eastern Telegraph Company's cable-ship "John Pender" on the 27th November, since which date the cable has worked well. The prevalence of bad weather, and the quantity of new cable inserted, brought the cost of the repairs to £4,050. 17s. 7d., including the value of cable from our stock. This amount has been paid by transferring £1,674 5s. 3d., the balance of the contingencies account, and by taking £2,376. 12s. 4d. from the reserve fund, and it is intended to repay this amount to the reserve fund out of future profits.

Some exceptional expenditure was incurred during the past half-year, the principal items being on account of the removal of our station at Marseilles to the new post office in that town, and special repairs effected on the underground cables at Falmouth and at Bilbao.

Of the balance of profit and loss, £2,500 have been put to the reserve fund (which now amounts to £26,445. 19s. 4d.), leaving £2,528. 12s. 11d. Out of this amount the Directors recommend the payment of the dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend at the rate of 4 per cent. per annum (free of income tax) on the ordinary shares, making, with the previous distribution, 4½ per cent. for the year 1891. A balance of £31. 13s. 4d. is carried forward. The dividend warrants will be issued on the 1st of April next.

Sir James Anderson and Mr. Denison Pender are the Directors retiring by rotation, and offer themselves for re-election. The auditor, Mr. Herbert R. Duke, retires, and offers himself for re-election.

Gülcher (New) Electric Light and Power Company (Limited).

The following report has been issued by the Directors of this Company, and will be submitted to the shareholders at the meeting to be held at Winchester House, E.C., on Monday, the 21st inst., at 12 o'clock.

The report and balance-sheet are for the twelve months ended June 30, 1891. The Directors have postponed the presentation until now in order that the Chairman might be able not only to interpolate such of the New Zealand accounts as are properly chargeable to the current year, but also to explain to the shareholders the results of his journey to the colony. It will be seen by the balance-sheet that the public lighting installation at Wellington (which was completed early in 1890) had cost the Company £13,486. 13s. 3d. to erect. This installation, which was producing a revenue of £1,750 per annum, reducible in three years to £1,600 per annum, was costing the Company nearly £1,300 per annum to maintain; and, as was pointed out in the last report, the commercial success of the undertaking depended entirely upon the provision of further capital for the supply of light to private consumers.

A syndicate which had then already been formed for this purpose, and to take over the public lighting business of the Company in the Colony, stipulated that Parliamentary powers from the New Zealand Legislature should be first obtained at the expense of the Company. The Corporation of Wellington had also set up a claim to be paid a sum, amounting to about £530 per annum, for water, which they alleged that the Company used in excess of the quantity which the Corporation had contracted to supply, and serious litigation appeared to be imminent. Under the circumstances, it was resolved that the Chairman should go to New Zealand, at the joint expense of the Syndicate and the Company, to settle, if possible, the disputes with the Corporation, and to apply for the necessary Parliamentary powers to enable the Company to sell its installation and the benefit of its contract to the Syndicate.

The Chairman's journey, although protracted far beyond anticipation, has been completely successful. The dispute with the Corporation has

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been satisfactorily arranged; Acts of Parliament, not only for Wellington but for Christchurch and Auckland, have been obtained; and the Corporation have assented to the sale by the Company of the Wellington Public Lighting Installation to the Syndicate. Could the proceeds of this sale be properly brought into the present year's accounts, the balance-sheet would show a profit of £3,000, or thereabouts, instead of a loss of nearly £1,200. The Acts, however, were not obtained until the end of September, and the final arrangements with the Corporation were not arrived at until November 26, 1891, so that the beneficial results of the Chairman's journey cannot appear until the next balance sheet is issued.

The particulars of the contracts entered into, and of the arrangements made with the Corporation of Wellington, will be supplied at the general meeting, when a detailed profit and loss account will also be submitted to the shareholders.

With regard to the loss shown upon the year's trading, this is distinctly traceable to the depression which fell upon business in England in the last three months of 1890 and the first six months of 1891, in consequence of the financial crisis in the City. For the first time during the last nine years the year's receipts from sales in England have decreased, and during the nine months above referred to they decreased by £2,500, while the business in New Zealand was temporarily at an enforced standstill. Since then the sales in England have again improved, and a new field has been open in the colony, which promises to be a large and permanent customer of the Company.

An agency was also opened in Italy last autumn, and the City of Genoa is already partly lighted by our Company. This agency also promises to prove an increasing business.

Since the last general meeting the Directors, under the powers conferred on them by the Articles of Association, have elected Captain W. S. Levett, a duly qualified shareholder, to a seat on the Board. Mr. Grëwing and Captain Levett retire by rotation from the Board, but being eligible, offer themselves for re-election. Mr. Russell Day, the auditor appointed at the last general meeting, also retires, but offers himself for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 303-322, *and in other parts of that book.*]

ASSINIBOIA IMPROVED LANDS (LIMITED).—Among the objects of the above-named Company, which was registered on March 8, 1892, with a capital of £50,000, in £5 shares, is included that of constructing, using, working, and carrying on railways, tramways, waterworks, gasworks, telegraphs, telephones, electric light, heat and power works, and undertakings of a similar kind.

CONCESSION AND INVESTMENT SYNDICATE (LIMITED).—This Company was registered on March 9, 1892, with a capital of £2,000 in £1 shares, by G. B. Bruce Paton, 20, Bucklersbury, E.C. The objects are to purchase or otherwise acquire a controlling or other interest in gas, water, and electric light companies in the United States of America, the British Colonies, or elsewhere; to adopt and carry out agreements for the acquisition of any concessions, rights, or interests relating to any gas, water, or electric works, businesses, and concerns in the United States of America, Canada, and elsewhere, and to maintain, manage, carry on, work, develop, lease, or exchange, any of the above-named businesses. Registered office: 20, Bucklersbury, E.C.

COSMO GEAR COMPANY (LIMITED).—This Company was registered on March 7, 1892, with a capital of £10,000, in £1 shares. Among the patents acquired is one for anti-friction wheels (No. 16,649, 1891) for driving gear for electric cars.

D. W. BARDILL AND COMPANY (LIMITED).—This Company was registered on March 8, 1892, with a capital of £8,000, in shares of £5 each, as manufacturers and dealers in chemical and other preparations, and electrical, chemical, photographical, surgical, and scientific apparatus and materials at Derby and Burton-on-Trent.

HAYCRAFT AND SON (LIMITED).—This Company was registered on March 12, 1892, with a capital of £10,000, in £1 shares, to carry on business as ironmongers, ironfounders, iron and steel merchants, manufacturers, mechanical engineers, braziers, coppersmiths, electro-platers, electricians, electric light engineers, lamp makers, bellhangers, bell manufacturers, &c., at Deptford and Lewisham.

METALLIC TUBE AND FLASK COMPANY (LIMITED).—This Company was registered on March 9, 1892, with a capital of £50,000, in £5 shares, as manufacturers of and dealers in all kinds of tubes, chemicals, medical, electrical, and chemical apparatus, and fittings of all kinds, &c. The business to be acquired is that of Messrs. Taylor and Challen (Limited), at Wiggin-street, Birmingham.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 12, 1892, was lodged at Somerset House on March 11, 1892, by Mr. Thomas Weaver, of 26, Old Broad-street, E.C. The nominal capital is £7,000,000 stock, all of which is fully paid.

BRITISH ELECTRIC INSTALLATION CONTRACTORS (LIMITED).—The statutory return of the above-named Company, made up to February 25, 1892, was filed on March 1, 1892. The Company was registered on October 12, 1891, with a capital of £20,000, in £5 shares. At the time of making up 242 shares had been taken up, of which 100 had been issued as fully paid. Upon the remaining 142 the full amount had been called, resulting in the payment of £575, and leaving £135 in arrears. No agreements for the acquisition of any business, contracts, plant, &c., have been filed. Registered office: 1, Angel-street, Worcester.

BROMPTON ELECTRIC FITTINGS COMPANY (LIMITED).—The second annual return of the above-named Company, made up to December 21, 1891, was filed on March 2, 1892. The Company was registered on April 20, 1889, with a capital of £2,000, in £1 shares, to acquire, promote, carry on, and extend the business of designing and manufacturing art metal fittings for electric light, gas, &c., and to manufacture and supply electric and other bells, heating apparatus, &c. At the time of making up 1,050 shares had been taken up, the full amount and all calls (£1,050) paid. The principal shareholders are B. Gee, electrical engineer (50); C. F. Tufnell, of Lloyd's, E.C., civil engineer (250); B. Gibson, of 1, Upper Westbourne-terrace, W. (250); F. R. Reeves, of Springfield, Little Heath, Potter's Bar (94); and John F. Albright, of 146, Brompton-road, S.W., engineer (400). Registered office: 146, Brompton-road, London, S.W.

CHLORIDE ELECTRICAL STORAGE SYNDICATE (LIMITED).—The registered office of this Company is 13 and 14, Abchurch-lane, London, E.C. (filed on February 20, 1892.) The Company was registered on December 12, 1891, with a capital of £262,500, in £1 shares (of which 250,000 were preference and 12,500 ordinary shares), and full particulars were published in *The Electrician*.

DEVON AND CORNWALL ELECTRICITY SUPPLY COMPANY (LIMITED).—The above Company was registered on June 28, 1889, with a capital of £100,000, to carry on the business of an electric light company. At the date of the last return (January 3, 1889), 42 shares had been taken up, the full amount called, and all calls (£210) paid. The Board of Trade having revoked the Provisional Order acquired by this Company, and no office (without which no business is allowed to continue) having been filed, it may be considered, we understand, that the Company has ceased to exist.

GÜLCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of the above Company, made up to December 31, 1891, was filed on March 9, 1892. The Company was registered on February 28, 1888, with a capital of £70,000, divided into 50,000 preference and 20,000 deferred shares of £1 each. At the time of making up (December 31, 1891) all the shares had been taken up, and the deferred shares had been issued as fully paid. Upon 12,277 of the preference shares the full amount had been called, and upon the remaining 37,723 preference shares 10s. per share had been called, resulting in the payment of £36,650. 1s. 4d., and leaving £175. 18s. 8d. in arrears.

NEWCASTLE AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 29, 1892, was filed on March 9th. The Company was registered on January 14, 1889, with a capital of £50,000, in £10 shares. At the time of making up (February 29, 1892) 3,075 out of the 5,000 shares had been taken up. Upon 2,138 shares £8 per share had been called, upon 430 shares £6 per share had been called, and upon the remaining 507 shares £4 per share had been called, resulting in the payment of £21,691, and leaving £18 in arrears.

CITY NOTES, &c.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—Particulars will be found in our advertisement pages of the issue of Four and a-Half per Cent. Perpetual Debenture Stock in this Company to the amount of £125,000 at the price of £101 per centum, for the purposes of redeeming the existing £75,000 Six per Cent. Mortgage Debentures of the Company and of providing additional capital for the increasing business. The interest upon these debentures is payable on the 1st March and the 1st September, the first interest for a full six months being made on the 1st September next. The present issue is made by the Electric and General Investment Company, Limited (who are trustees for the Debenture Stockholders), and is payable as follows: 10 per cent. on application, 41 per cent. on allotment, and 50 per cent. on the 1st of May next. As is well known, the Brush Electrical Engineering Company was formed in 1889 to take over the old business of the Anglo-American Brush Corporation, and also of the Falcon Engine and Car Works (Limited). The gross profit shown in the annual report, issued in September last for the year ending June, 1891 (exclusive of any profit from the business accruing to the Brush Company from its interest in the City of London Syndicate), was £39,916, and the actual value of the Company's assets, British and foreign, show a surplus of liabilities of nearly half a million sterling. The present debenture issue is secured by deposit of debentures and a trust deed, and will operate, as a first charge, as a floating security upon the whole undertaking and property of the Company (with the exception of the Vienna business, which is subject to a contemplated re-arrangement). The subscription list opened yesterday, and closes on or before Monday next at 4 p.m. for London, and 11 o'clock on the following day for the country.

CALIFORNIA GAS, WATER, AND ELECTRIC LIGHTING COMPANY SYNDICATE (LIMITED).—This Syndicate, which was formed in December last, is asking for a capital of £30,000 in £1 shares for that portion of its concession which it is proposed to transfer to the Los Angeles City and County Water Syndicate. Persons wishing to subscribe, or requiring particulars, can apply to Mr. G. B. Bruce Paton, 20, Bucklersbury, London, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the ten weeks ended Friday, the 4th inst., amounted to £33,917, and for the week ending 11th March £2,872. This Company's receipts will be published weekly.

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CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended March 13th were £676, as against £749 in the corresponding period of last year, showing an increase of £127. The total receipts to date, from January 1st, 1892, are £8,830, against £7,714, an increase of £1,116.

EUROPEAN SIMS-EDISON ELECTRICAL TORPEDO COMPANY (LIMITED). Major-General Alexander H. Elliot, C.B., and Captain H. F. Twynam have joined the Board of this Company.

ISLINGTON ELECTRIC LIGHT COMPANY (LIMITED).—"We (*Financial News*) learn that this Company is being formed with a capital of £250,000, and subscriptions will shortly be offered to the public. Sir Frederick Abel has been invited to join the Board, and the enterprise is said to have secured influential support."

SIAM ELECTRIC LIGHT COMPANY (BANGKOK).—This Company has, we understand, gone into liquidation.

FOOTBALL.—SILVERTOWN *v.* SIEMENS BROS.—The return match between the staffs of these firms was played at Charlton Park on Saturday last, and resulted in a win for Siemens Bros. by two goals and a try to nil. The first half of the game was pretty evenly contested, neither side scoring. At the invitation of Mr. Siemens, both teams dined in the evening at the Holborn Restaurant.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. March 9.		Price Wednesday, March 16.		Rate per Cent. Yielded.	Dividend Due.	Business done during Week ending March 16.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,[illegible]	Stock	16 0	Anglo-American	49	50	49¼	50¼	4 19 0	Jan., Apr., July, Oct	50	..
£2,849,51[illegible]	Stock	3 2/0	Do. Preferred	88	89	88½	89½	5 17 4	,, ,,	89¼	88½
£2 849,51[illegible]	Stock	5/0	Do. Deferred	11½	12	12	12¼	..	,, ,,	12¼	11⅞
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99	102	100	103	3 17 8	January and July ..	101⅜	..
130,000	£10	3/0	Brazilian Submarine	10¾	11½	10¾	11¼	7 2 3	Mar., June, Oct., Dec.	11¼	10¾
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock xd	155	160	151	156	4 9 9	Jan., Apr., July, Oct.	159¼	155⅜
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	10¹⅞	..
6,000	10	10%	Do. Preference 10%	16½	17½	16¼	17¼	5 14 3	,, ,,	..	..
12 931	5	2/0	Direct Spanish (£4 paid)	3¼	3½	3½	3⅞	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	8½	9½	8⅝	9½	5 5 3	,, ,,	..	..
60,710	20	3/6	Direct United States	11	11½	11¼	11⅝	6 3 4	Jan., Apr., July, Oct	11¼	11
400,000	10	2/6	Eastern	14⅜	14⅝	14⅜	14⅝	4 7 5	,, ,,	14⅜	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	,, ,,	15½	15¼
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108	111	108	111	3 2 1	May and November	110	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅞	15⅛	14⅞	15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	14⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	106	109	106	109	3 13 5	February & August	108	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102	105	102	105	4 15 3	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	101	104	101	104	4 16 2	,, ,,	103¾	102
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99	102	99	102	3 18 5	February & August	..	..
180,227	10	1 6	Globe Telegraph and Trust	9⅞	10¼	9⅞	10¼	5 6 2	Jan., Apr., July, Oct.	10¼	9¹³⁄₁₆
180,042	10	6%	Do. 6 per Cent. Preference	14⅝	15⅛	14⅝	15⅛	3 19 10	,, ,,	15⅛	14¼
180,000	10	5/0	Great Northern	18½	19¼	18¾	19¼	4 8 4	Jan., April, and July	19¼	18¼
£ 90,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	41⅜	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	7⅛	8	7⅛	8	5 3 2	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6% .... Oct. Coupon, 1891	117	122	115	120	5 0 0	,, ,,	120½	120
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 13 0	March & September	100¾	100
30,000	10	2 0	West Coast of America	4	5	4	5	..	January and July ..	4	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	..	..
88,321	10	1/0	West India and Panama	1⅜	1⅝	1⅜	1⅝	..	,, ,,	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½	10½	9½	10½	5 17 1	May and November	10½	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8½	9½	8¾	9¾	6 6 4	,, ,,	..	..
67,007	15	6/0	Western and Brazilian	10	10½	10¼	10½	6 19 5	,, ,,	10⅞	10½
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6	6½	6¼	6½	5 2 4	,, ,,	6⅞	6⅝
30,364	7½	7/6	Do. 5 per Cent. Deferred	3¾	4¼	4	4½	..	,, ,,	4¼	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102	105	102	105	5 14 3	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102	105	102	105	5 14 3	,, ,,	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	97	100	97	100	6 0 0	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance.	⅜	½	⅜	½	8 7 7	May and November	..	..
220,000	£1	4·7d.	Oriental (11s. paid)	¼	⅜	¼	⅜	6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅛	4⅜	4¼	4½	6 13 4	June and December	4⅜	4¼
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13½	12½	13½	4 8 11	,, ,,	13	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	11½	12½	11½	12½	4 16 0	,, ,,	12½	12
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	104	107	105	107	4 4 1	January and July ..	106⅜	10⁵⁄₈
58,000	5	1/0	United River Plate	1½	2½	2	3	..	,, ,,	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	80	90	85	95	5 5 3	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£6 paid)	8	8½	7¼	8¼	..	—	8¼	8⅛
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
8,332	£5	..	House to House Electric	4½	5	4½	5	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5½	6½	5½	6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5½	6½	5½	6	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 paid)	2⅝	2¾	2⅞	3	..	March	..	..
10,000	£5	4%	Do. (fully paid)	4⅜	5	4⅜	5	..	March	..	..
111,000	5	..	London Electric Supply	⅞	1⅛	⅞	1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8½	9	8⅝	9	..	..	8¾	..
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½	5½	4½	5½	—	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8½	8¾	8¾	8¾	—	..	8½	8¼
7,900	£5	7%	Do. 7% Preference	7¼	7¾	7¼	7¾	..	..	7⅝	7½
42,853	5	..	Westminster Electric Supply (fully paid)	6¼	6¾	6¼	6¾	..	..	6¾	6⅞
			ELECTRIC MANUFACTURING, &c., COMPANIES								
77,978	3	1/0	Brush Electrical Engineering	3½	3⅝	3½	3⅝	..	..	3½	3⅝
69,996	2	6%	Do. 6 per Cent. Preference	2	2¼	2	2¼	5 7 7	..	2⅜	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½	6	5½	6	5 16 8	January and July ..	6¼	..
17,130	5	17½	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	5¾	6¼	6	6¼	..	—	6⅛	6⅛
70,000	2	10/0	Elmore's Patent Copper Depositing	3	3¼	3	3¼	..	—	3⅛	3⅛
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & Telegraph Works	19½	20½	19½	20½	4 17 7	February & August	19½	19⅜
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	106	103	106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	3½	4½	4	5	..	..	..	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	½	⅝	⅝	¾	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	4	4½	4	4½	8 11 10	May and November	4⅝	4½
36,250	12	36/0	Telegraph Construction and Maintenance xd	44	46	43	45	5 6 8	March and July.....	43½	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July .	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½	1	½	1	6 0 0	..	..	..
—	£5	8%	Do. Preference (fully paid)	2¼	2¾	2¼	2¾	11 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
50,000	£10	—	City and South London Railway	2½	3½	2½	3½	..	—	3½	..

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THE ELECTRICIAN:

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NOTES.

The report and accounts of the London Electric Supply Corporation, which will be found in another column, call for little remark except at the hands of the shareholders, who meet to-day to stomach them with what appetite they can. The engineer's report states that during the autumn considerable difficulties were experienced in working at 10,000 volts; and there were occasional failures of the dynamos, transformers, and trunk mains, "many of which were due to the present arrangements for working the machines in parallel." Measures are, however, being taken by which, it is believed, these difficulties will be overcome.

The accounts show a total expenditure up to date of more than three-quarters of a million sterling, some £100,000 of which was expended during 1891. Deptford, with its plant and machinery, has cost no less than £280,000; mains have absorbed £148,000; and electrical instruments (not including meters) account for over £12,000. The sales of current by meter at 7¼d. per B.T.U., realised £13,783, which means that 456,265 units were sold. The "sheer cost" of production therefore comes to 5¼d. per B.T.U.; but adding distribution and management expenses the B.T.U. which was sold at 7¼d. cost the vendors nearly a shilling. It is interesting to note that while mains have absorbed no less than 45 per cent. of the Westminster Company's outlay, they only account for 20 per cent. in the case of the Deptford scheme.

The 6¾d. for distribution and management can, of course, be reduced almost in inverse proportion to the increase in the output, and it must be remembered that economy in this respect was held to be the strong point of the London Electric Supply Corporation; but the St. James's and Pall Mall Company spend only 2¾d. on this item. The "sheer cost" will, of course, be reduced also as time goes on, but with the large generating units, a steady load will be needed. The plant which is already arranged for, including the large dynamos which are partly finished, will suffice for just ten times the present number of lamps connected, while the building will provide room for as much again. The day may come when the London Electric Supply Corporation will supply current at 4d. per unit, but the progress towards that result is very slow.

The details of cost of electric light in mills, which will be found in our Notes columns, and for which we are indebted to the *Engineer*, should encourage mill owners as well as proprietors of other large establishments to carry out their own lighting. It is almost impossible to arrive accurately at the cost, especially when so few lamps are in use as in the present case. It is as easy to burden the expenses with heavy items of depreciation as it is to overlook cost of labour when part of a man's time only is employed. We have heard of a case in which the proprietor of a large mill, in estimating the cost of electric lighting, put down a proportion of interest and depreciation of the main chimney shaft and wear and tear of coal waggons, and satisfied himself that the expense would be five or six times that of gas. There are many, on the other hand, who say that electric light costs them practically nothing but lamp renewals, since this is the only item which appears on their books.

Much has been heard lately about oil as an insulator; but it was not until near the close of the discussion on Prof. Hughes' paper that attention was called by Prof. Ayrton to the important distinction between true resistance, opposition to spark discharge, and surface resistance. Mr. Gray and Mr. Cuthbert Hall were the only contributors to our knowledge of the true resistance, which has little if anything to do with sparking distance. The high sparking distance has led many people to think that oil is an extremely good insulator; and it has naturally been imagined that jute cotton or hemp, which have been used as mechanical separators, were the weak points of the system. It has, however, been pointed out that dry cellulose is one of the best possible insulators, and that the function of the oil is not to insulate the fibre, but to keep it dry. This throws an entirely new light on the question, and ought, we think, to give more confidence in the system than it has hitherto received. The surface leakage is, as Prof. Ayrton points out, a totally different matter, and concerns what are known as "oil insulators," though accurate measurements would be of little value for practical work, since the surface is liable to become dirty. The healing properties after a spark discharge must, of course, be completely different when a Wimshurst machine and an alternating dynamo and transformer are used.

In a Paper on Choking Coils, just read before the Physical Society, Prof. Perry upheld the much-debated theory that the loss of energy in transformers caused by hysteresis was

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very small, and implied that most of the losses which occurred were due to eddy currents. This view will find little favour among engineers until it is supported by more tangible evidence than is supplied by FOURIER's theorem; at the same time Prof. PERRY is probably right in emphasising the importance of eddy currents. It seems generally believed that if the iron be well laminated, the losses due to eddies are negligibly small. The losses due to this cause are, however, quite appreciable even in the best transformers, and the tendency of eddy currents to alter the distribution of the lines of force, causing them to be denser in some parts of the core than in others, may perhaps alter the hysteresis losses. The discrepancies which exist between the calculated and experimental values of the efficiency of various transformers seem to point to the fact that the irregular distribution of the lines of force, owing to magnetic leakage or other causes, affects, to an appreciable extent, the power lost in hysteresis.

THE question turned up in the course of the LANE-FOX case whether, supposing it was feasible in 1878 to use an earth return the intervention of the Board of Trade would "smash up the patent." The converse problem arises in the ingenious "double sealing" patent of Mr. FERRANTI. The Board of Trade have ordered that, "where any alteration is made in any certified meter, or where any such meter is unfixed or disconnected from the service lines, such meter shall cease to be a certified meter unless and until it be again certified." These regulations are to be enforced by the affixing of seals after certification; and Mr. FERRANTI has boldly patented a method of arranging these seals, which, if not the only practicable plan, is one which will require some ingenuity to evade. The cover or case of the meters, which are illustrated on p. 537 of the present issue, are fastened to the body of the instrument by screws which are sunk a little below the level of the case. The seals are fixed to these screwholes after certification, and the meter maker cannot afterwards get to the working parts. A recess is made in the lower part of the meter for the terminals of the cables; these having been attached, a cover is screwed on by the supply company, and seals are fixed by them, which prevent any tampering on the part of the consumer.

AT a recent meeting of the Paris Municipal Council, M. Lyon-Alemand, in the name of the Third Committee, asked for a vote of 40,000frs. to meet the increased expense consequent on the substitution of coke for coal at the Halles central station. He remarked that the Committee could not blame the officials for having conformed to a vote of the Municipality, but the Committee nevertheless felt obliged to remark that the cost of production of the electrical unit was thereby increased. Some few months ago, the Municipal Council was seized with a sudden desire to mitigate the smoke nuisance in Paris. It was, however, pointed out that the Municipality's own chimney at the Halles was one of the worst offenders in Paris, and that pending the discovery of the perfect smoke annihilator, only the use of coke would enable the Municipal Council to prosecute delinquent manufacturers with a clear conscience. This praiseworthy determination to first set its own house in order, and then by the sweet persuasion of the law to oblige others to do likewise, has thus cost the Municipality an altogether respectable sum.

THE Havre jeweller who warms his shop with an alternate-current transformer affords another example of the interest which is being taken in electrical heating for domestic purposes. Without going so far from home, we could point out a transformer chamber in London, constructed, as it should be, of thoroughly fire-proof materials, where a thermometer hung on the brick wall indicates 115° Fahr.

Telephonic Changes.—The business of the Mutual Telephone Company was taken over by the New Telephone Company on Wednesday last.

Erratum.—On p. 510 of our last issue, in the Note headed "A Mountain Electric Railway," for "36 cubic feet per second," read "706 cubic feet per second."

The Belgian Government and the Telephones.—It is officially announced that the Belgian telephones will be taken over by the Government on January 18th next.

Schmalkalden.—The Trusenthal waterfall, which gives a minimum power of 150 H.P., is about to be utilised for lighting the town of Schmalkalden by electricity.

Copper.—According to *The Statist* a combination is in negotiation among the big American and other copper producers to restrict the world's supply to the demand.

India-Rubber.—A company has been formed for the purpose of growing india-rubber on a large scale in Mexico. About 100,000 trees are to be planted in the State of Sinaloa.

Manila.—The Manila municipal authorities offer a concession for twenty years and a subsidy of £12,000 a year in reference to the electric lighting of the town. The contractor is to be at liberty to supply private houses.

Storage Battery Plate Capacity.—According to some tests of Prof. Dufour, of Lausanne, the capacity in ampere-hours of the following storage battery plates per lb. is as follows:—Huber, 6·6 E.P.S. 3·2; Reckenzaun, 3·27; Farbaky and Schenk, 5·1.

Electric Heating.—According to *l'Industrie Electrique*, a Havre jeweller, who has an alternate-current transformer installed in the basement underneath his shop, has placed an iron grating over it, and in this way warms his premises largely at the electricity supply company's expense.

Sydney, N.S.W.—Mr. Arthur C. F. Webb, M.I.E.E., has recently been appointed, by the Minister of Public Instruction, Lecturer on Electrical Engineering at the Sydney Technical College. Upwards of 60 students had entered for the course when the first lecture was delivered six weeks ago.

The Canadian Telegraphs.—Mr. F. N. Gisborne, Superintendent of the Government Telegraphs, has drawn up an elaborate report on the subject of the Canadian Government taking over the telegraphs of the Dominion. It will be presented to Parliament during the present Session.

The Chatham Accident.—In answer to a question asked in the House of Commons last week, the President of the Board of Trade stated that in consequence of the recent fatal accident the Chatham and Rochester and District Electric Lighting Company had been requested to make certain alterations.

The Paris-Brussels Telephone Line.—A further reduction is to be made in the telephone tariff between Paris and Brussels. A convention has been concluded between the French and Belgian Governments whereby the rate will be shortly reduced from 2s. 6d. for five minutes to 1s. 3d. for the same space of time. A third wire is on the eve of completion.

Taunton.—The Joint Committee of the Town Council, who have had the matter of the purchase of the electric light works

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under consideration, have issued an elaborate report. The capital of the Company is £20,000, and the Borough Surveyor considers the purchase money should be about £10,000. At a noisy meeting of the ratepayers, held on Monday, a resolution adverse to the purchase was carried.

The Electric Light in Night Manœuvres.—On Saturday last the London Rifle Brigade executed some night manœuvres at Elstree, with a view of testing the utility of the electric light. The portable military search-light was placed on the rising ground on which the village of Elstree stands. From this position it completely commanded the surrounding country. The attacking force was shown up at long ranges, and kept well exposed throughout the operations.

Lord Kelvin.—"We do not think it indiscreet," says *La Lumière Electrique*, "to inform our readers that there is much talk at the Académie des Sciences of nominating Lord Kelvin as successor to the late Emperor of Brazil as one of the eight foreign associates. . . . It would certainly seem desirable that the Académie des Sciences should take this opportunity of adding an honour to that which the English Government has just rendered to the illustrious electrician which the Royal Society of London has honoured with its presidency."

Breslau.—The first six months' work at the central station erected by Messrs. Siemens and Halske in Breslau shows gross receipts amounting to £7,500; the expenditure, including the writing off of a proportion of the capital outlay, being about £6,300. At present 14,000 lamps are at work. The battery of 420 Tudor cells seems to give great satisfaction. As a rule the machines are run only from 5:30 to 10 o'clock daily, and on Sundays only for three and a-half hours. During the summer months it will only be necessary to run every other day.

Royal Institution.—The following are some of the lecture arrangements after Easter:—Mr. Frederick E. Ives, two lectures on Photography in the Colours of Nature; Prof. Dewar, four lectures on the Chemistry of Gases. The Friday evening meetings will be resumed on April 29th, when a discourse will be given by Dr. William Huggins on the New Star in Auriga; succeeding discourses will probably be given by Captain Abney, Dr. B. W. Richardson, Mr. J. Wilson Swan, Sir James Crichton-Browne, Mr. Ludwig Mond, Prof. Dewar, and others.

Cable Extensions.—The Eastern Extension Company have recently laid a cable (161 knots in length) between Penang and Sumatra, and have since entered into a contract with the Dutch Government to connect Olehleh (Acheen) and Laboean Deli (291 knots). This cable is being manufactured, and will be sent out about the end of April. These connections will give a triplicate route between Penang and Singapore and Penang and Banjoewangie (Java), and thus bring the important tobacco-growing districts into telegraphic communication with the rest of the world.

Simultaneous Telegraphy and Telephony.—The Picard system of simultaneous telegraphy and telephony (see *The Electrician*, Vol. XXVII., p. 560), together with the Van Rysselberghe and other similar systems, are to be experimentally tested by Mr. Preece next month over the London-Paris lines. Preliminary comparative trials are now being made between Paris and Nantes. As we stated some little time ago, the Picard system is in operation between Paris and Troyes and between Bordeaux and Arcachon. Van Rysselberghe's system is also used on several French lines.

The Paris Telephone System.—A Bill is now before the Chamber of Deputies asking for a vote of £160,000 for the purpose of reorganising the Paris telephone network, for which object a total of £320,000 will ultimately be required. The twelve existing exchanges are to be replaced by four large ones, situated in the Rue Gutemberg, Avenue de Wagram, Place de la République, and Avenue des Gobelins. Between September 1, 1889, and January 1, 1892, the telephone subscribers have augmented by 3,475, increasing the annual receipts by over £40,000.

The Electric Railway Schemes.—In the House of Commons on Monday, Mr. Whitmore moved—"That the resolution of the House of March 1st, relative to Electric and Cable Railways (Metropolis)., which was ordered to be communicated to the Lords, and the message from the Lords of March 7th, signifying their concurrence in the said resolution, be read; that the said Select Committee appointed to join with the Committee of the Lords do consist of five members, to be nominated by the Committee of Selection; that a message be sent to the Lords requesting their Lordships to appoint an equal number of Lords to be joined with the members of this House." The motion was agreed to.

Southport.—At a recent special meeting of the Town Council, convened to consider the supply of electricity for lighting by the Corporation, it was unanimously resolved—(1) That the installation be fixed at or near the gas works, and worked on the high-tension alternating-current system; (2) that plans for the buildings and plant be prepared as soon as possible; (3) that Mr. G. Wilkinson, of London, be appointed the engineer, his inclusive remuneration to be at the rate of 3 per cent. on the outlay. All questions of cost, street lighting, the the extension of the scheduled area, and the price to be charged (which, however, must not exceed 8d. per unit), were left for future consideration.

Bristol.—The buildings at the Temple Back station—like the foundations—are to be of a more extensive and substantial character than was at first contemplated; but it is hoped that the original estimate of £60,000 will not be exceeded. It has been decided to advertise for tenders for the erection of the station and stack, and also for boilers, engines, dynamos, and everything necessary for the station. The Electric Lighting Committee have determined to buy Lancashire boilers and Willans engines. A pamphlet is to be prepared setting forth the relative cost of electricity and gas. The plans for the central station have been prepared by Mr. Henry Williams, architect to the committee, and they provide for a substantial building of about 140ft. long, with an average depth of 100ft.

American Institute of Electrical Engineers.—In view of the projected International Conferences at the Chicago Exhibition, this Institute, which has done excellent work, has issued a pamphlet, briefly sketching its past history. Since its foundation, in 1884, the Institute has been the medium for the publication of a large number of useful and highly practical Papers, many of which have been reproduced in our columns. Amongst these we may cite that of Mr. A. E. Kennelly, on "Inductance and its proposed Unit the Henry;" Prof. Ryan's, on "The Effect of the Air Gap in Dynamos;" Mr. Tesla's, on "High Frequency Currents;" and many others of equal worth. It is hoped that the attention drawn to the work of the Institute, which now numbers some 600 members, will induce electrical engineers who purpose visiting Chicago next year to bring themselves into closer touch with American ideas by joining its ranks.

Cambridge.—A special meeting of the Town Council was held at the Guildhall on Thursday last week. The Electric Lighting Committee reported that Messrs. Parsons and Co. had offered to undertake to commence the electric light within the area of supply not later than the commencement of the next October term, and to proceed continuously with all possible despatch. The system employed would be the alternating-current system. The charge per unit should not in any case exceed 7d., and the Company would pay £1,000 towards the expenses of the Corporation, who should have the power to acquire the undertaking at the end of 21 years, upon paying for the undertaking as a going concern. The Committee considered the terms to be fair and reasonable, and recommended the Council to adopt them, and to instruct the Town Clerk to prepare an agreement in accordance with the provisions contained in the Provisional Order relative to the transfer of the powers of the Corporation under the Order. This report was unanimously agreed to.

Glasgow.—The Corporation having purchased a piece of ground 91 × 89ft. at the corner of Waterloo-street and Main-street for the purpose of erecting a central generating station, the contracts for the necessary buildings have been let, and

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the work of erecting them is proceeding. It is intended in the first instance to put down plant capable of supplying 12,000 8 c.p. lamps. The station, however, will be sufficiently large to contain plant for the supply of 40,000 lamps. The chief building will be three stories in height. At the beginning there will be five steel boilers of the marine type, 10ft. in diameter and 12ft. in length, having a working pressure of 160lb. The engines will be Willans'. Of these there will be seven —two of 80 H.P., two of 150 H.P., and three of 250 H.P. Two of the seven dynamos will have an output of 400 amperes at 120 volts, two an output of 400 amperes at 230 volts, and three an output of 670 amperes at 230 volts. The current is to be distributed by means of copper strips placed in cast-iron troughs. It is anticipated that the station will be open by the end of August, and that some of the chief streets of the city will then be lighted with arc lamps. A sum of £8,000 has been paid for the ground. The erection of the buildings will absorb a sum of from £10,000 to £12,000, while a further sum of from £40,000 to £50,000 will be required for machinery and conductors, bringing up the total expenditure to between £60,000 and £70,000.

Large Glass Cells.—Hitherto glass cells have been blown, and owing to this their size has been very limited, the largest being only about 22in. long by about 12in. or 14in. deep, and the same in width. By the process now successfully carried out by Armstrong's Glass Company, of Birmingham, tanks and cells of any dimensions can be constructed. The process consists in welding or fusing plates or sheets of glass together, thus forming a solid glass tank, with all the advantages of having the sides straight, the bottoms level, and the angles all square and to accurate measurements, the blown boxes being frequently quite the reverse in these respects. Armstrong's Company show at the Crystal Palace one tank 4ft. 6in. long, made by their new process, which is briefly as follows:— A mould of iron of the interior dimensions of the tank is placed into a furnace, and upon this mould are fastened the plates of glass. The furnace is gradually heated until red hot. Then an oxyhydrogen blow-pipe, or an electric arc burner, is introduced to heat the edges. A small roller which is attached to the blow-pipe is next brought over the junction, and the joint formed. When all the joints have been finished the cell is left to anneal, and when perfectly cold the glass box or tank, thus formed out of five glass plates welded together, is lifted off the iron mould, being a perfect tank, solid throughout, and capable of resisting acids and alkalies. The same Company show an underground conduit for electric cables, formed of slabs of glass, grooved with longitudinal parallel grooves. In laying these, after the trench in the ground has been formed, a cement concrete trough is made; inside this trough a layer of pitch or asphalte is run in. Upon this soft pitch the bottom sections of the glass slabs are placed. Upon these the upper section of the glass slabs are placed, the joints being broken by each section. The whole is then run in with pitch or asphalte, and covered up with the concrete.

The London County Council Subways Bill.—On Tuesday this Bill came before the Select Committee of the House of Commons, presided over by Mr. H. Gladstone; Mr. Cripps appeared for the Electric Lighting Companies and the Telephone Companies. The Bill proposes that the County Council should have the power to extend the system of enclosing underground wires and pipes in an easily accessible subway instead of burying them in the earth, so as to mitigate the expense and annoyance caused to the public by the frequent cutting up of the streets. There are now nine streets in which these subways already exist, Garrick-street, Southwark-street, Commercial-road, Queen Victoria-street, the Victoria Embankment, Northumberland-avenue, Shaftesbury-avenue, Charing Cross-road, and Rosebery-avenue, comprising altogether 7,810 yards of subway, and these existing subways are under the control of the London County Council. Mr. Littler, in opening the case for the promoters, mentioned as an instance of the annoyance that was caused by there being so many bodies with powers to cut up the streets, that when the West Strand was repaved, no sooner had it been done than the water company came along and took up the whole of one side of it, and after they had done with it the gas company took up the other side. The subways had cost several thousand pounds a mile, and he thought it reasonable that something in the shape of rent should be paid for the use of them. The first witness called was Mr. A. Binnie, engineer-in-chief to the London County Council, who said there were in their subways 15,043 yards of gas pipes, 7,614 yards of hydraulic pipes, 6,492 yards of water pipes, 15,770 yards of telegraph and telephone wires, and 7,117 yards of electric wires. On Wednesday Mr. Cripps, Q.C., cross-examined on behalf of the Electric Lighting Companies, mentioned that the electric companies were not satisfied. Professor Forbes, who had been consulted in respect of the proposals of the Bill, testified that it would be to the public benefit to have the electric wires in the metropolis placed in the subways, that it would be a great advantage and saving to the electric companies, and that there would be no danger through the juxtaposition of the wires with various pipes. The Committee adjourned until Monday, in the hope that in the interval the differences between the opposing companies and the County Council would be cleared away altogether.

The Cost of the Electric Light in Mills.—The following facts relating to the electric lighting of some large steam mills at Barrow-in-Furness, belonging to Messrs. Walmesley and Smith, are from the *Engineer*. The installation, which was laid down in 1885, includes a Mather-Platt dynamo, driven through countershafting by a horizontal steam-jacketed Marshall engine, supplied with steam at 65lb. pressure from the mill boilers. The dynamo runs at 1,115 revolutions, the engine at 120 revolutions. Some 150 100-volt 16 c.p. Edison-Swan lamps were installed. The dynamo was started on March 6, 1885. The total outlay was £420. 10s. 11d.

General Working Expenses, Maintenance and Renewals.

—	1885-6.	1890-1.
	£ s. d.	£ s. d.
Interest (5 per cent.)	20 0 0	15 9 3
Depreciation	20 0 0	15 9 3
Fuel consumed (calculated at 3½lb. per I.H.P.H.)	22 5 6	47 17 6
Lamp renewals	22 5 0	9 10 9
Brush renewals	6 14 0	0 18 0
Commutator renewals	8 10 0	—
Fixing commutator and repairing ditto	4 8 7	0 10 0
Sundries and renewals	0 19 0	—
	105 2 1	84 14 9

Details of Lamp Hours and Lamp Hour Cost.

Number of hours run	3,163	3,477
Average number of lamps lit	100	127
Number of lamp hours	316,300	441·579
Cost per lamp hour	·079d.	·048
Number of lamps lit—one hour for 1d.	12·6	20·8

Renewals and Repairs.

Number of lamps renewed	95	59
Number of times commutator turned	8	2
Number of brushes used	8	1

Taking the average for the six years we have—Annual cost, £91. 19s. 11d.; cost per lamp hour, ·059d.; hours run, 3,392; lamps lit, 112·1; lamp hours, 380,243. The cost of gas in Barrow = 3s. per 1,000 cubic feet, so that the cost of an equal number of No. 5 burners, consuming 5½ cubic feet per hour at 3s. = £313. 13s. The 16 c.p. 100-volt lamp hour at ·059d. is equivalent to the Board of Trade unit at about ¾d. The average life of each lamp comes out at 3,384 hours, and there are two or three of the original lamps still burning, having run over 20,000 hours. The figures supplied with regard to the commutators are instructive: the first lasted 8½ months, the second 12, the third 24½, the fourth 14½; the fifth commutator, still in use, has run 3,500 hours, and has been turned up twice.

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ELECTROMAGNETIC THEORY.—XXVI.

BY OLIVER HEAVISIDE.

(Continued from page 453.)

§ 126. The simplest and most easily understood effect of ∇ upon a function is when it acts upon a scalar, say P. This implies that P is a scalar function of position, or of x, y, z. In the most important applications P is single-valued, as when it represents density, or pressure, or temperature, or electric potential, or the corresponding magnetic potential of magnets. But P may also be multiplex, as when it is the magnetic potential outside a linear electric current. At present let P be simplex.

By (119) we have

$$\nabla P = \mathbf{i}.\nabla_1 P + \mathbf{j}.\nabla_2 P + \mathbf{k}.\nabla_3 P. \quad . \quad . \quad . \quad (137)$$

Of course, since ∇ is vector and P scalar, the result is a vector. Its meaning is easily found. From the fact indicated in (137) that the rectangular scalar components of ∇P are the rates of increase of P along the axes of **i**, **j**, **k**, we may conclude that the component of ∇P in any direction is the rate of increase of P in that direction. Thus, **N** being any unit vector, we have, by (137),

$$\mathbf{N}\nabla P = N_1\nabla_1 P + N_2\nabla_2 P + N_3\nabla_3 P. \quad . \quad (138)$$

Comparing with (121), we see that

$$\mathbf{N}\nabla P = (\mathbf{N}\nabla)P = dP/ds, \quad . \quad . \quad . \quad (139)$$

by (123), s being length measured along **N**.

The identity of $\mathbf{N}\nabla P$ and $\mathbf{N}\nabla$. P is tolerably obvious algebraically. It is not, however, true when for P is substituted a vector, as we shall see later.

If we take P = constant, we obtain the equation to a surface. If, then, **T** is any tangent to the surface at a chosen point, that is, any line in the tangent plane perpendicular to the normal, we shall have $\mathbf{T}\nabla P = 0$. The direction of ∇P itself is therefore that of the normal to the surface; or the lines of ∇P cut the equipotential surfaces perpendicularly, and pass from one to the next (infinitely close) by the shortest paths. The distance between any two consecutive equipotential surfaces of a series having a common difference of potential varies inversely as the magnitude of ∇P, and ∇P itself is the vector showing at once the direction and the rate of the fastest increase of P. No perfectly satisfactory name has been found for this slope, or space-variation of a scalar function. Comparing P with height above the level on a hillside, ∇P shows the greatest slope upwards. But the illustration is inadequate, since on the hillside we are confined to a surface.

The tensor of ∇P is given by

$$(\nabla P)^2 = (\nabla_1 P)^2 + (\nabla_2 P)^2 + (\nabla_3 P)^2, \quad . \quad (140)$$

as with any other vector.

We may also here notice the vector product $V\mathbf{N}\nabla$ in its effect on a scalar. We have, by the semi-Cartesian formula for a vector product,

$$V\mathbf{N}\nabla = \mathbf{i}(N_2\nabla_3 - N_3\nabla_2) + \mathbf{j}(N_3\nabla_1 - N_1\nabla_3) + \mathbf{k}(N_1\nabla_2 - N_2\nabla_1). \quad (141)$$

Thus, when the operand is scalar, as P, we shall have

$$(V\mathbf{N}\nabla)P = V\mathbf{N}\nabla P. \quad . \quad . \quad . \quad . \quad . \quad (142)$$

The result is a vector perpendicular to the plane of **N** and ∇P, as in any other vector product, vanishing when they are parallel, and a maximum when they are perpendicular.

§ 127. When the operand of ∇ is a vector, say **D**, we have both the scalar product and the vector product to consider. Taking the former alone first, we have

$$\text{div}\,\mathbf{D} = \nabla\mathbf{D} = \nabla_1\mathbf{D}_1 + \nabla_2\mathbf{D}_2 + \nabla_3\mathbf{D}_3. \quad . \quad . \quad (143)$$

This function of **D** is called its divergence, and is a very important function in physical mathematics. Its general signification will be best appreciated by a consideration of the Theorem of Divergence.

Let liquid be in motion. The continuity of existence of the matter imposes certain restrictions on the motion. The current is $m\mathbf{q}$ per unit area, where m is the density and **q** the velocity. But, to further simplify, let $m = 1$, making the liquid incompressible. Then the current is simply **q**, which measures the amount of liquid crossing unit area of any surface perpendicular to **q**. But if the surface be not perpendicular to **q**, the effective flux is only **Nq**, the normal component of **q**, if **N** denotes the unit normal to the surface. Therefore, $\Sigma\mathbf{Nq}$, or the summation of **Nq** over any surface, expresses the total flux of liquid through the surface.

Now suppose the surface (fixed in space) is closed. Then the summation represents the amount of liquid leaving the enclosed region per second through its boundary, if **N** be the outward normal. This amount is evidently zero, because of the assumed incompressibility. If then we observe, or state, that $\Sigma\mathbf{Nq}$ is not zero, either the fluid is compressible, or else there must be sources of liquid within the region. Adopting the latter idea, because it simplifies the reasoning, we see that the summation $\Sigma\mathbf{Nq}$ is the appropriate measure of the total strength of the sources in the region, since it is the rate at which liquid is being generated therein, or the rate of supply. The position of the internal sources is quite immaterial, and so is the shape of the region, and its size, or the manner in which a source sends out its liquid (*i.e.*, equably or not in all directions). So we have

$$\Sigma\mathbf{Nq} = \Sigma\rho, \quad . \quad . \quad . \quad . \quad . \quad . \quad (144)$$

if ρ represents the strength of a source, and the Σ includes them all.

When the sources are distributed continuously, so that ρ is a continuous function of position, its appropriate reckoning is per unit volume. That this is the divergence of **q** is clear enough, according to the explanations relating to divergence already given. That it is the same as $\nabla\mathbf{q}$, as in (143), we may prove at once by the Cartesian form there exhibited.

We have to reckon the flux outward through the sides of a unit cube. Take its edges parallel to **i**, **j**, **k** respectively. Then there are two sides whose outward normals are $-\mathbf{i}$ and **i**, and their distance apart is unity. The outward fluxes due to them are therefore $-\mathbf{iq}$, or $-q_1$, and $q_1 + \nabla_1 q_1$, whose sum is $\nabla_1 q_1$. Similarly the two sides whose normals are $\pm\mathbf{j}$ contribute $\nabla_2 q_2$, and the remaining sides contribute $\nabla_3 q_3$. Comparing with (143), we verify the Cartesian form of the divergence of a vector.

But we may have any number of other special forms, according to the co-ordinates we may choose to employ for calculating purposes, such as spherical, columnar, &c., and the most ready way to find the corresponding form is by the immediate application of the idea of divergence to the volume-element concerned. For purposes of reasoning, however, it is best to entirely eliminate the idea of co-ordinates. Divergence is independent of co-ordinates.

The sources need not be so distributed as to give rise to a finite volume-density. We may have, within the region concerned, surface-line or point-sources, and the principle concerned is the same throughout. Thus the density of a surface source is measured by the sum of the normal fluxes on its two sides per unit area, that is, by $\Sigma\mathbf{Nq}$ applied to the two sides of the unit area, if the flux wholly proceeds outwards. This is, however, not fully general, as there may be a flux in the surface itself, so that the full measure of the surface density has to include the divergence of the surface flux, to be found by calculating the flux leaving the unit area across its bounding line. Similar considerations apply to linear sources. In the case of a point-source the measure of the strength is the flux outward through a closed surface enclosing the point infinitely near it—the surface of the point, so to speak. Any other surface enclosing the point will do, provided there are no other sources brought in by the change. There may also be multiplex sources. Thus, a pair of equal point-sources, one a source, the other a sink, would be equivalent to no source at all if brought infinitely near one another; but if the reduction in distance be accompanied by a corresponding increase in strength of the sources, the final result is not zero. This is the case of a magnetised particle on the theory of magnetic matter; but it is not necessary or desirable to complicate matters by entering

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upon special peculiarities of discontinuity in considering the Divergence Theorem. Its general form being

$$\Sigma \mathbf{ND} = \Sigma \operatorname{div} \mathbf{D}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (145)$$

when the vector **D**, to which it is applied, admits of finite differentiation, the special meanings to be attached to the divergence of **D**, in order to satisfy the principle concerned, may be understood.

Although a material analogy, as above, is very useful, it is not necessary. Any distributed vector magnitude will have the same peculiarities of divergence as the flux of a liquid. If it be the motion of a real expansible fluid that is in question, then the divergence of its velocity represents the rate of expansion. It would, however, be very inconvenient to have to carry out this analogy in electric or magnetic applications; an incompressible liquid, with sources and sinks to take the place of expansions and contractions, is far more manageable.

§ 128. The following way of viewing the Divergence Theorem, apart from material analogies, is important. Consider the summation $\Sigma \mathbf{ND}$ of the normal component of a vector **D** over any closed surface. Divide the region enclosed into two regions. Their bounding surfaces have a portion in common. If, then, we sum up the quantity **ND** for both regions (over their boundaries, of course), the result will be the original $\Sigma \mathbf{ND}$ for the complete region. The normal is always to be reckoned positive outwards from a region, so that on the surface common to the two smaller regions **N** is + for one and − for the other region, and $\Sigma \mathbf{ND}$ for one is the negative of that for the other, so far as the common surface goes.

Since this process of division may be carried on indefinitely, we see that the summation $\Sigma \mathbf{ND}$ for the boundary of any region equals the sum of the similar summations applied to the surfaces of all the elementary regions into which we may divide the original. That is,

$$\Sigma \mathbf{ND} = \Sigma \phi(\mathbf{D}), \quad . \quad . \quad . \quad . \quad . \quad (146)$$

where, on the right side, we have a volume-summation whose elementary part $\phi(\mathbf{D})$ is the same quantity $\Sigma \mathbf{ND}$ as before, belonging now, however, to the elementary volume in question. We have already identified $\phi(\mathbf{D})$ with the divergence of **D**.

But if this demonstration be examined, it will be seen that the validity of the process whereby we pass from a surface to a volume summation, depends solely upon the quantity summed up, viz., **ND**, changing its sign with **N**. We may therefore at once give to the Divergence Theorem a wide extension, making it, instead of (146), take this form:—

$$\Sigma \mathrm{F}(\mathbf{N}) = \Sigma f(\mathbf{N}). \quad . \quad . \quad . \quad . \quad (147)$$

Here, on the left side, we have a surface, and on the right side a volume summation. The function $\mathrm{F}(\mathbf{N})$, where **N** is the outward normal, is any function which changes sign with **N**. The other function $f(\mathbf{N})$, the element of the volume summation, is the value of $\Sigma \mathrm{F}(\mathbf{N})$ for the surface of the element of volume. Thus, by considering a cubical element,

$$f(\mathbf{N}) = \nabla_1 \mathrm{F}(\mathbf{i}) + \nabla_2 \mathrm{F}(\mathbf{j}) + \nabla_3 \mathrm{F}(\mathbf{k}) \quad . \quad . \quad (148)$$

is the Cartesian form, should $\mathrm{F}(\mathbf{N})$ be a scalar function, or the semi-Cartesian form should it be a vector function. A few examples of the general theorem (147) will be given later. In the meantime the other effect of ∇ should be considered.

§ 129. The vector product of ∇ and a real vector, say **E**, is given in semi-Cartesian form by

$$\begin{aligned} V\nabla\mathbf{E} &= \mathbf{i}(\nabla_2 \mathrm{E}_3 - \nabla_3 \mathrm{E}_2) + \mathbf{j}(\nabla_3 \mathrm{E}_1 - \nabla_1 \mathrm{E}_3) + \mathbf{k}(\nabla_1 \mathrm{E}_2 - \nabla_2 \mathrm{E}_1) \\ &= \operatorname{curl} \mathbf{E}. \quad . \quad . \quad . \quad . \quad . \quad (149) \end{aligned}$$

As before, with respect to the divergence of a vector, we can best appreciate the significance of this formula by the general property involved, expressed by the Theorem of Version.

On any surface draw a closed curve or circuit. Let, for distinctness, **E** be electric force. Calculate the voltage in the circuit due to **E**. The effective force per unit length of circuit is the tangential component of **E**, or **TE**, if **T** is the unit tangent. The voltage in the circuit is, therefore, $\Sigma \mathbf{TE}$, the summation being circuital, or a line-integration extended once round (along) the closed curve.

Now draw on the surface a line joining any two points of the circuit. Two circuits are thus made, having a portion in common. Reckon up the voltage in each of the smaller circuits and add them together. The result is the voltage in the first circuit, if we rotate the same way in both the smaller circuits as in the original, because the common portion contributes voltage equally and oppositely to the two smaller circuits.

This process may be carried on to any extent by drawing fresh lines on the surface. We therefore have the result that the voltage in the circuit bounding a surface equals the sum of the voltages in the elementary circuits bounding the elements of surface. Or

$$\Sigma \mathbf{TE} = \Sigma \theta(\mathbf{E}), \quad . \quad . \quad . \quad . \quad . \quad (150)$$

where on the left side we have a circuital summation, and on the right side an equivalent surface summation, in which $\theta(\mathbf{E})$, the quantity summed, is the value of $\Sigma \mathbf{TE}$, that is, the voltage in the circuit bounding the particular element of surface concerned.

To find the form of θ in terms of **i**, **j**, **k**, &c., we need only calculate the voltages in unit square elements of surface taken successively with edges parallel to **j**, **k**, to **k**, **i**, and to **i**, **j**. In the first case, when the normal to the square circuit, or the axis of the circuit, is **i**, the voltage is

$$\nabla_2 \mathrm{E}_3 - \nabla_3 \mathrm{E}_2,$$

that is, by (149), the **i** component of $V\nabla\mathbf{E}$, and therefore the normal component, since here $\mathbf{N} = \mathbf{i}$. Similarly when $\mathbf{N} = \mathbf{j}$, and the axis of the circuit is **j**, the voltage in it is expressed by the coefficient of **j** in (149). And when $\mathbf{N} = \mathbf{k}$, the voltage is the coefficient of **k** in (149). Thus, in any case, the voltage in an elementary circuit of unit area is the normal component of $V\nabla\mathbf{E}$, that is, $\mathbf{N}V\nabla\mathbf{E}$. So (150) becomes

$$\Sigma \mathbf{TE} = \Sigma \mathbf{N}V\nabla\mathbf{E} = \Sigma \mathbf{N} \operatorname{curl} \mathbf{E}, \quad . \quad . \quad (151)$$

expressing the Theorem of Version, sometimes termed Stoke's Theorem.

When **E** is not electric force, $\Sigma \mathbf{TE}$ is not circuital voltage, but circuital something else; but this does not affect the general application of the theorem.

This theorem is particularly important in electromagnetism because it is involved in the two fundamental laws thereof, what were termed the First and Second Circuital Laws, or Laws of Circuitation, connecting together the electric and magnetic forces and their time variations. (*See* §§ 33 to 36, Chap. II., and later.)

If the vector whose curl is taken be velocity **q** in a moving fluid, then curl **q** represents twice the spin or vector angular velocity of the fluid immediately surrounding the point in question; its direction being that of the axis of rotation, and magnitude twice the rate of rotation. But I have not made use of the fluid analogy in describing and proving the Version Theorem, because it is not of material assistance.

Since the validity of the process whereby we pass from a circuital summation of the tangential component of a vector to an equivalent surface summation depends upon the fact that **TE** changes sign with **T**, we may generalise the theorem thus:—

$$\Sigma \mathrm{F}(\mathbf{T}) = \Sigma f(\mathbf{T}), \quad . \quad . \quad . \quad . \quad . \quad (152)$$

where on the left we have a circuital and on the right a surface summation, and $\mathrm{F}(\mathbf{T})$ is such a function of **T** as to change sign with **T**; whilst $f(\mathbf{T})$, the element of the surface summation, is the value of the former $\Sigma \mathrm{F}(\mathbf{T})$ for the particular element of surface in question. Of this general theorem a few examples will be given later.

A few words regarding ∇, div and curl, terminologically considered, may be useful. Since divergence and curl are expressible in terms of vex (a provisional name for ∇, which has been suggested to me), why not use the vex operator only, like the quaternionists? The reasons, which are weighty, should be obvious.

In the first place, we require a convenient language for describing or referring to processes and results, expressing approximately their essential meaning without being too mathematical. Now ∇ alone is not convenient for this purpose. The scalar product of ∇ and **D** conveys no such distinct idea, as does

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divergence; nor does the vector product of ∇ and **E** speak so plainly as the curl or rotation of **E**.

Besides, the three results of ∇, exemplified in ∇P, and ∇**D**, and ∇ ∇ **E**, are so remarkably different in their algebraical development and in their meaning, that it is desirable, even in the algebra, to very distinctly separate them in representation. Therefore, in the preceding part of the present work (as in all former papers), the symbol ∇ is only prefixed to a scalar, as in ∇P, the space variation of P, whilst for the scalar and vector product are employed div and curl, in the formulæ as well as in descriptive matter.

There are, however, cases when it may be desirable to use ∇ and V∇ applied to vectors in formulæ, namely, when the combinations of symbols are not so simple that their meaning and effect can be readily seen, and when it is required to perform transformations also not readily recognisable. The utility of ∇ in its vectorial significance then becomes apparent, for one may use it alone, temporarily if desired, and work it as a vector, remembering, however, its other functions. Of this, too, some examples should be given.

(To be continued.)

FERRANTI ELECTRICITY METERS.

Mr. Ferranti has devoted considerable attention to electricity meters ever since their first inception. Patents have been taken out by him embodying alternating or continuous current meters, meters having shunt compensating circuits, and "double sealing," *i.e.*, a fastening for the part to be certificated, and a fastening to protect against interference with the connections, since rendered essential by the regulations of the Board of Trade, &c., and with which all Ferranti meters are provided. The Ferranti meters are substantially constructed, and, while being accurate recorders, they are designed so as to be suitable for the position and usage to which appliances of this kind must necessarily be more or less subject. Completely enclosed in metal cases they are both air and watertight.

Continuous-Current Meter.—The essential principle of the Ferranti continuous-current meter (Fig. 1) is, as is well known, the measurement of the rotation of a bath of mercury through which the current passes from the periphery to the centre after energising a magnetic field; the lines of force being at right angles to the radial direction of the current in the mercury. The speed of rotation increases in direct proportion to the current, and the movement is transmitted to the register by a fan which is mounted on a light spindle and immersed in the bath. The registering of the meter is as simple as the mechanism. The face is marked with six dials, units, tens, hundreds, &c., and the amount registered on these, when divided by the constant stated in the instructions issued with the meter, gives the number of Board of Trade units consumed. A feature of the Ferranti meter is the extremely small amount of energy required to work it, and the consequent absence of any observable drop in pressure due to resistance or work being put in series with the lamps. There is only one moving part, and this is perfectly enclosed in a metal case, entirely inaccessible, and is unaffected by external influences. The correctness of its record would not be impaired by a magnet being placed near it, as might be done by a dishonest consumer. It is, indeed, a motor meter of the simplest form, and as such does not require to be touched for winding up or recalibration. It is made entirely of uninflammable material, can be quickly installed and connected, and is suitably designed to prevent it being tampered with afterwards.

The Ferranti meter will, at its best, start registering at ·4 per cent. of its limiting load, and will register with less than 3 per cent. error over 95 per cent. of its working range. For instance, a 100-ampere meter will start registering at ·35 ampere, and will register correctly from less than five to 100 amperes.

Size.	Maximum Revs. per Minute	Starting Current.
100-ampere meter	275	0·35
50-ampere meter	250	
25-ampere meter	275	
10-ampere meter	220	

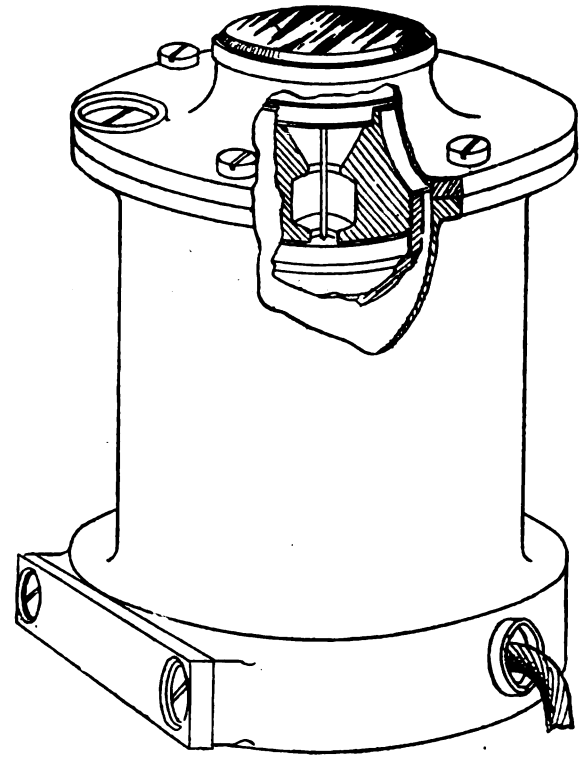

Fig. 1.—Ferranti Electricity Meter for Continuous Currents.

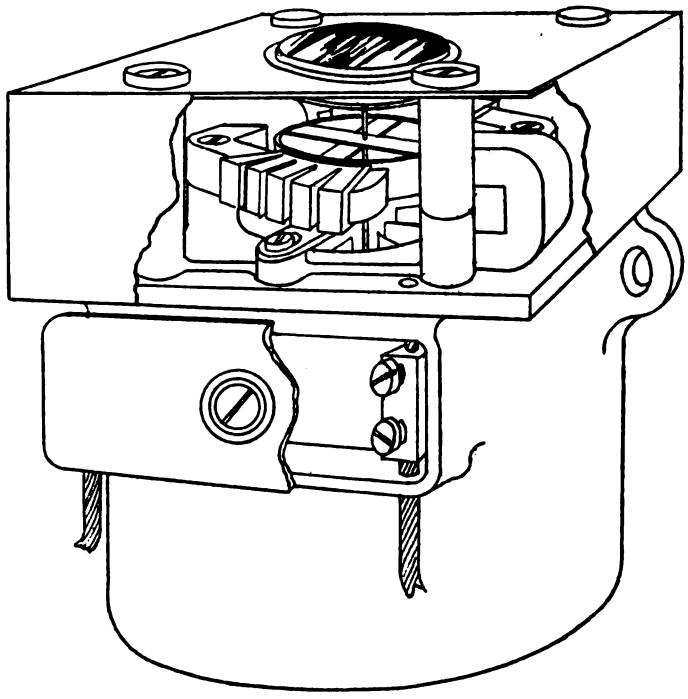

Fig. 2.—Ferranti Electricity Meter for Alternate Currents.

Alternate-Current Meter.—The alternate-current meter designed by Mr. Ferranti in conjunction with Mr. Arthur Wright consists essentially of a small non-synchronous motor, having a rotary field, through the magnet windings of which the current flows. The armature (Fig. 2) is a small metal disc, revolves at a speed proportionate to the current, and is geared directly to the counting train. The meter is enclosed

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in a metal case, and embodies the double sealing to which reference has already been made. A diagrammatic view of the internal arrangements of this meter as seen from above is given in Fig. 3. The pole pieces of the magnet, it will be observed, are

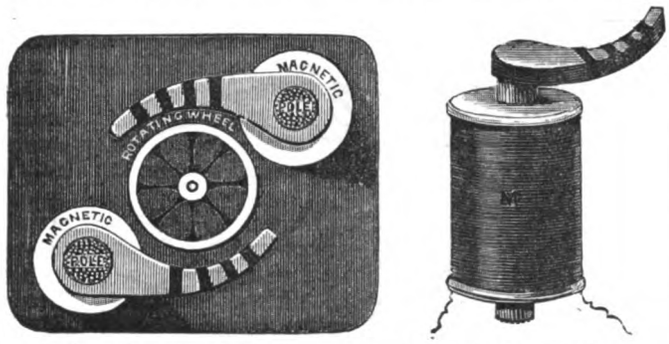

FIG. 3.—Diagrammatic View of Ferranti Alternate-Current Meter.

curved, the iron being divided in a horizontal plane. These horn-like protuberances, which are "magnetically" throttled at intervals by encircling copper bands, embrace the revolving metal disc forming the armature of the meter. The *modus operandi* of the apparatus is somewhat as follows:—The throttling of the curved iron horns causes the lines of force to issue from the circuit in a series of "puffs," setting out laterally from the sides of the horn, and travelling up it. The passage of these lines through the rim of the revolving wheel generates eddy currents in it, which are continually repelled by the field moving along the pole-piece.

The particulars given below are of unshunted meters.

Size.	Maximum revs. per minute.	Maximum watts consumed.	Starting current.
80 amperes	450	9·0	2·0 to 2·5
60 ,,	450	9·0	1·5 to 1·8
40 ,,	450	9·0	1·0 to 1·2
20 ,,	450	9·0	0·5 to 0·6
10 ,,	416	9·0	0·3 to 0·4

THE LONDON CHAMBER OF COMMERCE AND THE TELEPHONE SERVICE.

A deputation waited on the Postmaster-General on Monday afternoon from the London Chamber of Commerce, for the purpose of laying before him the views of the commercial community with regard to the telephone system of the country.

Sir ALBERT ROLLIT, M.P., in introducing the deputation, said that it was representative of the commercial feeling, not only of London, but, as he believed, also of the country. The reason they had come to the Postmaster-General was because the London Chamber of Commerce had, for a long time past, taken a very great interest in the subject of telephonic communication—so much interest that it had in connection with it an association for the purpose of watching the development of matters, and doing its best to improve and promote communication by means of the telephone and otherwise. The ground upon which they came was entirely a public one. The object of the Chamber had been and was to procure the best and cheapest mode of telephonic communication. The Chamber knew perfectly well, from its familiarity with business, that nowadays despatch was an essential element of profit, and that unless communication were good it was not possible to compete with other nations in relation to cost of production and the like. The opinion of the Chamber was that every possible facility should be given in our own country for similar commercial advantages. With the object of testing public feeling on the subject a conference was recently held at the Chamber, when he had the honour of being in the chair, and when a very impartial, and certainly a very prolonged, hearing was given to the views of all parties who were interested in that most important subject. The telephonic companies, both the existing one and the proposed new one, were represented, and equally the commercial public was largely present. What passed at that meeting was briefly this: that those who represented commerce complained in strong terms that the existing facilities were neither so great nor so cheap as the existing state of commerce demanded. On the other hand, the telephonic companies urged that they were in want of those powers the possession of which was essential to the proper performance of the duties entrusted to them. The deputation did not on this occasion propose to enter upon the discussion of that question. The feeling of the meeting was, he thought, distinctly that powers were claimed on behalf of the companies which were of a large character, and which, if granted, would lead to a great amount of private and public inconvenience. In that respect the existing company claimed rights which would give them the privilege of going upon private property, and, in a measure, of interfering with the use of it under statutory powers. Equally public authorities who at present possessed rights in relation to the user of the roadways, and so on, would have those rights infringed upon because the roadway could be taken, and overhead wires in almost an unlimited quantity, and very often at by no means proper heights, could be placed. There was no security given for the greater use of what he thought was so very essential, namely, underground wires, and he noticed that even estuaries were proposed to be invaded under the Bills which were before Parliament. That meeting having patiently heard all that was to be said on the question, came ultimately to this resolution, which he put before the Postmaster-General as expressing the considered views of the London Chamber of Commerce:—"That in view of the importance of the telephone industry, and the fact that two separate Companies have Bills before Parliament, this Chamber should appoint a deputation to apply for an interview with the Postmaster-General, and express the views of the Chamber as to the supreme importance of Her Majesty's Government bringing a General Powers Bill into Parliament, so as to confer facilities for the development of the telephone, not only in the metropolis, but also with regard to the inter-town services all over the country, whether by private companies or by the Government." The feeling of the Chamber and of the public, as far as he could judge, seemed to be that in the case of the Bills presented by each of those companies they were Bills distinctly of a private character. They created no obligation to confer telephonic facilities, they prescribed no limitation of the cost at which those facilities were to be given, they placed no limitation on the dividend which was to be paid; and, briefly, they scarcely so much contemplated public rights and advantages as private property to the companies themselves. On the other hand, they thought that if the Government brought in a Bill of the general character which had been indicated, and giving powers which undoubtedly were in some cases urgently required, but giving those powers subject to conditions which the Government might be able to prescribe in a Bill of that character, and enabling not only the Department which the Postmaster-General represented, but its licensees, to do those things which were absolutely necessary for telephonic development, subject to proper limitations for the protection of the public—they thought that a measure of that character was required for telephonic purposes, and would be of great public advantage. Viewing the matter in that light, with the object of serving the public and at the same time properly encouraging private enterprise, but encouraging the latter under proper limitations and restrictions, and giving a control power which those Bills did not certainly contain, they thought that that was the proper course to pursue, and that was a course which they came to strongly urge upon the Government. He had the honour to introduce the deputation, and to state that the resolution expressed the sentiments of the London Chamber of Commerce, and he asked the Government strongly to take the matter in hand in the public interest, and to introduce a General Powers Bill, which would do much to advance telephonic communication and competition under proper rights and restrictions. He would now ask Mr. Faithfull Begg, who was present at the meeting of the London Chamber of Commerce, and who took an interest in the subject, to add to the remarks which he had made.

Mr. FAITHFULL BEGG said the Chamber of Commerce had come to the conclusion that the telephone was a great public convenience and commercial facility, but that its development had not reached anything like the scope or extent in this country which might be realised under more favourable conditions. Looking at the history of the telephonic industry in Great Britain, he thought there were two chief reasons why it had not developed as it might have done. The first was undoubtedly the absence of statutory provisions or facilities whereby wires could be run independently of the caprice of individuals. It had frequently been the case that a city line—a line in a town like London—had had to be taken a very long distance out of the direct route merely because one particular attachment on an individual roof could not be obtained upon reasonable terms. The same applied to the trunk-wire communication in the country, where the local authorities had in many cases absolutely refused to consider any applications for the running of wires, no matter how urgent these might be; and consequently the routes had been blocked. The other reason which he thought had delayed the development of the industry had been, he said it with diffidence in the presence of Sir James, the restrictive policy of

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the Department. The Department, of course, had a great public property to protect in the telegraph; and naturally in the early stages of the industry it was not easy to quite see what facilities ought to be given or withheld. But undoubtedly as time had gone on the Department, he thought, had not shown a sufficiently liberal spirit in dealing with the companies. He would point out that quite recently the Telephone Company in London offered to connect up all the post-offices with their system, so that the public might have the free use of it from all these various points. A more important direction in which the Department had exercised its power had been in connection with their right of way-leave over railways, where they had not allowed, so he understood, the companies to pass under any circumstances.

The POSTMASTER-GENERAL: That is a mistake, they allow them to pass on payment of rather a heavy way-leave.

Mr. FAITHFULL BEGG: At all events, proper facility has not been granted. What was wanted was not that any individual company should be favoured, but that some means should be found whereby to properly constituted companies necessary facility should be granted, either through the Department, or direct under a Bill similar to the Electric Lighting Bill, in order that the difficulties under which they laboured should be removed.

The POSTMASTER-GENERAL: Mr. Lamb informs me that the request referred to to connect with the post-offices has never been made since the late Postmaster-General, Mr. Fawcett, made the existing settlement with the companies.

Mr. Sheriff FOSTER, speaking on behalf of the subscribers of the Telephone Company in London, said the resolution of the Chamber, of course, went beyond London; but, after all, he thought London, with its very large needs, was, perhaps, at the present moment about as inefficiently served as any large town in the United Kingdom. The London consumer paid about the maximum price for about the minimum amount of efficiency. The charge in London at the present moment was twice as much, and even three times as much, as the charge in some of the other towns in the kingdom. They were told that this charge was to a large extent due to the difficulty of getting way-leaves at anything like a reasonable rate in London. Therefore, it appeared obvious that some statutory power ought to be conferred upon the authorities who had the power to lay the telephone wires to establish their way-leaves compulsorily, under, of course, proper provisions for compensation. Some power for dealing with the opening of the streets should, he thought, also be granted them. Whether the Department could not, perhaps, more easily deal with the question of the streets, and then, perhaps, place in the hands of the company, or competing companies, the power to supply the telephone, he would not venture to indicate.

Mr. W. C. JACKSON said he represented a powerful voluntary association, known as the Telephone Subscribers' Protection Association. That association sprang into existence in consequence of a meeting which was summoned nine months ago at a public hall in Cannon-street, at which no less than 400 dissatisfied telephone subscribers attended. That meeting was only summoned by public advertisement, and the attendance represented a very strong feeling on the part of the body of London subscribers. That association existed only for the purpose of benefiting the subscribers to telephones in London. It was not in antagonism to the existing system, except in so far as that was inefficient; it desired to show no favour to any other system than that which would give the best communication. Since their association had made itself felt there had been, he thought, considerable improvements in the telephonic system in London. There had most undoubtedly been much greater attention on the part of the *employés*. He would impress upon him the fact that Mr. Sheriff Foster, when he spoke individually, nevertheless spoke with the same voice as not less than 1,000 members who have banded themselves together for the sole purpose of benefiting their common interests. There were two classes of persons for whom he himself spoke, the persons in large business or practice, to whom £20 was a small item, but to whom celerity, clearness, and other things were a first essential; and the very considerable number of smaller persons to whom £20 a year was a very serious matter.

Mr. SYDNEY MORSE, on behalf of that section of the public which was represented by the electric lighting industry, said that section was a very large industry now. The Board of Trade had granted a great many orders, of which at the present time 160 were effective. With the exception of some 20 or 30 metropolitan orders, each of those orders represented a district as large as Leeds, or Manchester, or Liverpool, and so on throughout the country. The telephone companies said that they did them a great deal of harm, and were one of the causes of their service being inefficient. They, on the other hand, said that the telephone companies could carry on their business with much greater efficiency and without being damaged in any way by the electric light industry if they would carry it out in accordance with modern principles of telephonic communication. They simply asked that their interests should be considered. They fancied the telephone companies claimed an absolute right to earth for their business; but what the electric light companies said was that if the telephone business could be carried on as stated without being damaged, that improved system ought to be adopted by the telephone companies. They themselves were under statutory powers, those powers being in effect the right to break up streets, in return for which the Board of Trade had the right to lay down regulations to see that they carried on their business in a reasonable manner. They thought if the telephone companies claimed large rights they ought to be put under regulations which would protect everyone, and would not be detrimental to their system. He was simply asking that the existing interests under the Electric Lighting Acts should be taken into special account.

Sir ALBERT ROLLIT said that those were the speakers who desired to address the Postmaster-General. At the same time it was only right that he should say there were two bodies represented who had not had any spokesman that day, but who had abstained upon the condition that they should put the matter impartially before him. He desired to say that neither of them in relation either to their management or their Bills should be considered to be prejudiced. They were Col. Jackson and Mr. Gane as representing the National Telephone Company, and his Grace the Duke of Marlborough as Chairman of the New Company; and therefore the observations of the speakers, as far as they had regard to the Bills, must be taken as being put before the Postmaster-General not controversially, and not certainly as having been answered.

The POSTMASTER-GENERAL, in reply, after intimating his regret that his room afforded but inadequate accommodation for the large number of gentlemen composing the deputation, said: I suppose, in reference to the last remark that Sir Albert Rollit made, that the promoters of both the private Bills, both the National Company and the New Company, would say that they were in favour of your general object; for undoubtedly they must, even in their own interest, desire that the London telephonic facilities be increased, and that the restrictions which stand in the way of their extension by means of the companies should be removed. Ever since I came to the General Post Office, I have given anxious and particular attention to the subject which you have brought before me to-day; and I shall be prepared, when the private Bills promoted by the two companies or groups of companies come on for second reading to-morrow, to make a general statement as to the policy of the Government and the scheme which the Government has formed for the promotion of the objects which you have represented to-day. It would be impossible, and it would not be respectful to the House of Commons, to anticipate that statement; but I can assure you that the matter is one to which the Government have given much attention, and I would add that their objects will be promoted and supported by the interesting statements you have made to me just now. I think I could not add anything to that at the present time, but I am exceedingly glad that you have put your views before me.

Sir ALBERT ROLLIT, on behalf of the deputation, thanked Sir James Fergusson for having granted them the audience; and the deputation then withdrew.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, March 25th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1) "On the Electromotive Forces of Gold and Platinum Cells." By Prof. Herroun. (2) "On a New Instrument for showing the Effects of Persistance of Vision." By E. S. Bruce, M.A. (3) "Some Electrical Instruments." By R. W. Paul.

OLD STUDENTS' ASSOCIATION.

7.30 p.m. Smoking Concert at the Masons Hall Tavern.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Posy Rings." By Dr. John Evans, F.R.S.

TUESDAY, March 29th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed: "On Mean or Average Annual Rainfall, and the Fluctuations to which it is subject." By Alexander R. Binnie, M.Inst.C.E.

WEDNESDAY, March 30th.

CHEMICAL SOCIETY.

4 p.m. Annual Meeting. President's Address; Election of Office Bearers and Council.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Foreign Exchange." By Ewing Matheson.

FRIDAY, April 1st.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert at St. James's Hall Restaurant.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Motion of the Ether near the Earth." By Prof. Oliver Lodge, F.R.S.

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THE GOVERNMENT AND THE TELEPHONES.

On Monday, December 21, 1880, it was decided by Mr. Justice STEPHEN that telephones were telegraphs, and consequently the monopoly of the Post Office. By this fortunate legal decision a powerful Government department was given a splendid opportunity of rendering at the same time a great public service and clearing itself from the imputation that its vision was limited to the length of its nose. Had it risen for a moment above the narrowest revenue considerations, it might have seen in GRAHAM BELL's invention an instrument of great utility, destined, if energetically worked, to extensive use, and likely, therefore, to ultimately become a source of income. At least, the telephone might have been frankly accepted and countenanced. It was, however, decided to levy a tax of 10 per cent. upon the gross receipts of companies sufficiently enterprising to provide a town or district with a telephone service, and to discourage the too rapid growth of a dangerous competitor. But the telephone was not to be snuffed out; and, 10 per cent. tax and other departmental impediments notwithstanding, it has progressed, though at a rate considerably slower than in countries where a more public spirited policy has been pursued, until its insidious inroads into the telegraph revenue has necessitated a *volte face* on the part of the Post Office. In future, said the Postmaster-General in the House of Commons on Tuesday night, on rising

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to oppose the second reading of the New Telephone Company's Bill, the greatest encouragement will be given to the development of the telephones, and the Post Office will work entirely in alliance with them. Why any other policy but this should have ever been adopted is now only a matter of interest to the student of history. We have it from the Postmaster-General himself that the cold-shoulder attitude has been a failure, in that it has not prevented the growth of the telegraph revenue being checked, although it has succeeded in getting things telephonic into such an inextricable tangle that in London, the largest and busiest city in the world, the telephone is not used one quarter as much as in Berlin, a capital but little more than one quarter its size.

Such has been the policy of the Post Office in the past, and such its result; what its exact future policy is to be we cannot tell until the Government Bill is introduced next week, but enough was said by Sir James Fergusson on Tuesday to leave little else than mere details to be supplied. At present the telephone companies are restricted from delivering messages, they are not allowed to place call boxes in post-offices, they cannot run their lines along railways, roads, and canals where the Post Office have entire concessions without paying heavy wayleaves, there is no connection between telephones and telegraphs, and no powers to run the wires either underground or overhead. In future there is to be no restriction on the delivery of messages, call-boxes are to be placed in post-offices wherever possible, the charges for wayleaves will be reduced to a nominal sum, we are to be permitted to telephone our telegrams to telegraph offices, moderate powers for running overhead wires will be conferred on the Post Office licensees, and the Post Office itself will undertake to run the inter-exchange wires underground.

All this, it is needless to say, is not going to be done merely out of an amiable desire to increase telephonic facilities, or to assist the National Company in its task of dividend earning. These concessions, we are told, if granted without corresponding provisions for the protection of the public revenue, would be very dangerous; for if the telephone companies were in communication with all the large towns, and sent messages all over the country, the system would to a large extent supersede the use of the telegraph, and consequently largely diminish the telegraph revenue. Rather than contemplate such a terrible contingency as that, the Government propose—to boldly take over the entire telephonic system of the United Kingdom, as they might have done last summer on favourable terms,—no, not at all; they propose to take possession of the trunk wires. On the face of it, there is, from the telegraph revenue point of view, a logical completeness about the idea which at once commends it. So far as inter-house telephony is concerned it has rather created a new habit than superseded an old one; and it may be doubted whether the growth of an exchange appreciably diminishes the rate of increase of the telegraph business in the town in which it is situated. Inter-urban telephony, on the other hand, is evidently destined to largely take the place of inter-urban telegraphy. It seems, therefore, but logical that the Post Office should seize the one and leave the other. Dual control, however, is not as a rule conducive to efficiency. It is to be hoped, moreover, that the Post Office intend to devote plenty of money to increasing the number of trunk wires. Something like half a million sterling has been expended within the past few years on our existing telephone trunk communications, and even with the comparatively high tariffs at present in vogue and other restrictions the lines are fully occupied. With tariffs reduced, restrictions removed, and the inter-urban lines converted into public telephonic highways, the copper that will be required will be something prodigious if the service is to be up to the high standard we are accustomed to expect from the Post Office electricians.

The outcry against the National Company has been loudest in London, and it is the Metropolis which will be but indirectly affected by the grand new Post Office scheme. London telephone subscribers complain of indifferent service and excessive charges, and would prefer a radical improvement in these matters to cheaper communication with Liverpool, and permission to telephone their telegrams whenever cross-talk and leakage currents permit of so delicate an operation. It is certainly true that the getting of wayleaves is to be facilitated by the Government Bill, but the wayleave difficulty is only *one* cause of the present inadequate service. Everything seems to point to the ultimate acquisition by the Government of the entire telephonic system of the United Kingdom. Then why take two bites at the cherry?

REVIEWS.

Traité Pratique d'Électricité. Par Felix Lucas. (Paris: Baudry et Cie.) To be obtained from *The Electrician* Printing and Publishing Company, 1, 2, and 3, Salisbury-court, Fleet-street, E.C.

While this work undoubtedly contains a very large amount of valuable matter, we cannot congratulate the author on his choice of subjects or on his arrangement of them. The book professes to be written chiefly for technical readers; yet the first part of it, consisting of no less than 160 pages, is entirely devoted to the mathematical theory of electricity. The writer has shown great skill in dealing with this difficult part of the subject; and although most of the proofs given are necessarily only slightly modified forms of those previously published, yet a very fair amount of originality has been shown in the arrangement of them, and in the introduction of simple geometrical methods and illustrations. A practical treatise should, however, approach the subject from the physical side. The mathematical theory of potential, and the discussion of Green's and other analogous theorems, are quite out of place in a work of this kind, however admirably they may be handled. The notions conveyed are not such as are needed in the latter part of the book, and the few practical ideas which are really necessary cannot possibly be gained from a merely analytical treatment of the subject. Indeed, much that is inserted in theoretical works on electricity might be with advantage reserved entirely for purely mathematical treatises. The elaborate theory of solenoidal and lamellar distributions of magnetism must always appear a waste of time to anyone acquainted with the eccentricities of iron; and it seems absurd to discuss the law between current elements, as is done at great length in Chapter VIII., when only closed circuit currents exist.

Besides this theoretical portion of the book there are five other parts, entitled electrical measurement; cells, accumulators, and electrostatic machines; dynamos; the transmission, distribution, and transformation of electrical energy; and finally the technical applications of electricity. The chapters are of irregular merit, some being excellent, and others very short and scrappy. The best part of the book is that dealing with dynamos. The character of the fluctuations of the armature current in various types of machine is considered fully, many new diagrams being given in illustration. The magnetic circuit and the phenomena of hysteresis are also well treated.

Several diagrams are given illustrating the properties of characteristic curves, and in particular a method is given for obtaining the characteristic of an alternator, taking into account the inductive nature of the armature. The design of dynamos is illustrated with an example worked out numerically; a novel and praiseworthy feature of the book. The work really deals with too many subjects to treat them

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at proper length; and this fault is very apparent in the second part, which could be amplified with much advantage. The chapter on transformers discusses the theory of them in the usual unsatisfactory manner; for after stating distinctly that the coefficients in the equations cannot be considered constant, the writer proceeds to treat them as if they were. In this way results are obtained which are of slight value in theory, and of no value in practice. To assume that the coefficients are constant is to assume that there is no loss of energy in the iron core; and as this waste of energy is the greatest waste which occurs in transformers, the assumption is absurd from a practical standpoint.

A rather fundamental mistake of the author is to use the terms "watt," "watt second," and "watts per second" over and over again, as if they had identical meanings. This mistake cannot be excused in the writer of a text-book.

The book consists of 600 pages of well-printed matter, and is plentifully illustrated.

Die Versorgung von Städten mit elektrischem Strom. By F. Uppenborn. (Berlin: J. Springer; and Munich: R. Oldenbourg.)

This book is a compilation of the Reports made for the Congress of the German Municipal Authorities on the occasion of their visit to the Frankfort Exhibition last August. The work of the editor seems to have been confined to arranging the Papers which were supplied by the various firms at the invitation of the Exhibition Committee in alphabetical order. This is to be regretted, as owing to the omission of all mention of central stations built by one or two of the best-known foreign companies, the publication just falls short of being thoroughly representative of continental practice. If the book is to be regarded as anything more pretentious than a collection of Papers (as would appear to be the case from its title) it would have been much better if the recapitulations of various methods of distribution and so on had been put together at the commencement. As it is, practically identical descriptions (of the three and five-wire systems, for instance) are repeated in different Papers.

The descriptions of central stations that are given leave little to be desired; and with the numerous beautifully got up plates will serve to give those who were not so fortunate as to get to Frankfort last year a very good idea of the great difference that exists between electrical practice on the Continent and in England.

Continental Electric Light Central Stations. By Killingworth Hedges. (London and New York: E. and F. N. Spon. 1892.)

Like "Die Versorgung von Städten mit elektrischem Strom," of which nearly the whole of the present work is a translation, this book would be greatly improved if the elementary descriptions interspersed throughout it were collected together and thoroughly boiled down. A certain amount of arrangement is aimed at, Part I. being devoted to high-tension systems, and Part II. to low-tension distribution. A summary of the central stations described is also given. An error occurs both in this and in the text in respect of the Pontresina installation. The transmission in this case is not affected by alternating currents, but by direct ones, although by coupling three machines in series a tension of 4,500 volts is obtained. The author's descriptions are not always quite satisfactory; this is specially noticeable in his treatment of the multiple-phase systems, and also of Bláthy's alternating-current meter, which is practically nothing but a rotating field motor. His method of expressing himself is, in several places, worse than vague; we are apparently told, for instance, on p. 9, that the Zipernowsky cut-outs, "which are somewhat after the Hedges system," are all of 10 H.P. In dealing with the Cassel station he does not evidently think it necessary to explain how "the usual difficulty of starting these (alternate current) motors is met by using the accumulators to bring up their speed." A reference to the German shows that it is done by running as motors the continuous-current dynamos to which the alternator is coupled. In his explanation of the ground plan of the Barmen station, on p. 78, he gives "cart-house" as the equivalent of "waagehaus." The picture ought to have saved him from this error.

In Part III. the author gives some good remarks on the position of gas companies with regard to electric lighting, and on the cost of the electric light abroad, which to a great extent explain the rapid extension of the system of distribution from central stations on the Continent. The table on p. 198, giving the equivalent price of gas compared with electricity at various prices per unit, although it does not take into account the effect of running at high efficiencies on the life of glow lamps, will be useful for forming comparisons of the cost to consumers in many towns where renewals are undertaken by the company. The "explanation of technical terms" at the end contains some poor definitions, and as it includes many words that do not occur elsewhere in the book (unless it is in the advertisements, *e.g.*, "carboid,") it would have been better omitted.

Most of the remarkably fine illustrations in the German original are also included in the present volume.

The Illustrated Catalogue of the "Compactum" Specialities. By John Kirkaldy and Co. (Limited), 40, West India Dock-road, London, E.

This publication, although styled a "Catalogue," contains a considerable amount of interesting information and articles on feed-water heating and purification for boilers, together with many useful engineering tables and data. Drawings showing general arrangements of the connections and sections of feed-water heaters, valves and pumps, are given, as are also descriptions of the various manufactures of the firm.

There is an article on condensing and heating, in which various reasons and data are given proving that coiled tubes give very much more efficient results than straight tubes,—in one case a thermal conductivity of 914·4 B.T. units per hour per square foot of heating surface per degree Fahr. of difference of temperature between inside and outside of tube, which is nearly the same rate as Joule obtained by passing water through the annular space between two tubes, the inside one carrying steam, when 1,000 units per degree difference of temperature were obtained. The importance of supplying hot feed to boilers is emphasised by the statement that in a boiler 18ft. long with the temperature at the bottom 60° F., and the steam at the upper part 324° F., there is a difference in expansion of $\frac{3}{8}$ths of an inch between top and bottom; hence severe straining would result. To meet this, more especially on board ship, but also in those land installations where perhaps neither the waste gases nor the exhaust steam can be conveniently utilised, Messrs. Kirkaldy recommend their live steam-feed heater. They claim that, besides obviating the straining of the boilers as well as purifying the feed-water to a great extent, it will give an actual economy in the amount of coal consumed. As the heat imparted to the feed-water is actually derived from live steam, this may at first sight appear somewhat inconsistent with the laws of thermo-dynamics; but it is well known, and proved by experiment, that heating surfaces are more efficient when in contact with water approaching boiling point, owing to the more rapid circulation as compared with colder water, while grease and other impurities are kept back in the heater, the result being equivalent to an augmentation of the boiler-heating surface. The importance of eliminating pernicious impurities from the feed-water is treated; and it is mentioned that a boiler evaporating 1,000 gallons per hour of water containing 30 grains of solids per gallon would collect 100lb. of deposit in 24 hours.

We are glad to observe that the practice of embodying in trade catalogues information useful to those for whom the catalogue is intended is a growing one; and Messrs. Kirkaldy are certainly not behind others in this respect. The catalogue is well printed and bound.

BOOK RECEIVED.

"L'Année Électrique." By Ph. Delahaye. (Paris: Baudry et Cie.)

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THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 482.*)

§ 72. **Advantages of the Current Weigher.**—It appears then that if the fixed coils are so arranged that their action upon the suspended coil is a maximum, the only quantity which has to be found with great accuracy is the ratio A/a. To this feature Lord Rayleigh attaches great importance. "The ratio of galvanometer constants can be accurately determined by the purely electrical process of Bosscha without linear measurement of either; and from this ratio we can pass to that of the mean radii by the introduction of certain small corrections of the second order." The theory of this method was explained in § 29.* "In this way all that is necessary for the absolute determination of currents can be obtained without measurements of length or of moments of inertia or even of absolute angles of deflection. The forces are, however, evaluated in gravitation measure, so that the final result requires a knowledge of gravity at the place of observation; but except through this quantity there is no reference to the units of space or time."

Thus in the ideal state of things, when dM/dx is a function of A/a only, an estimation of a current by a current-weigher involves only two observations of the first importance, viz., the determination of the ratio of the radii of the fixed and suspended coils, and the determination of the mass whose weight balances the electro-magnetic force experienced by the suspended coil. The first of these quantities is a constant of the instrument, and may be determined once for all. The second quantity has to be measured at each observation of the strength of the current; but this is exactly the same as the ordinary process of weighing, and is quite simple and very accurate. There are, of course, some other observations to be made, but these appear only in the form of small corrections.

In Lord Rayleigh's current-weigher the distance between the fixed coils was not adjustable. They were arranged in the Helmholtz fashion, so that the distance between the coils is equal to the radius of either. This is the ideal construction when the radius of the suspended coil is very small compared with that of either of the fixed coils. When, as in Lord Rayleigh's case, the ratio a/A is not very small, the fixed coils should have been somewhat nearer together than was actually the case. Thus the force experienced by the suspended coil was not quite a maximum, and accordingly the calculated force was not quite independent of small uncertainties in the measurement of the distance between the two fixed coils. But in Lord Rayleigh's apparatus the error introduced into the calculated value of the current by an error of 1 per cent. in the measurement of the distance between the two fixed coils only amounted to ·14 per cent., while this distance was easily measured with very considerable accuracy. Thus Lord Rayleigh was fully justified in the hope that his work was practically free from any error due to uncertainty in the distance between the fixed coils.

§ 73. **Insulation of the Coils.**—If the reader will refer to § 49 he will find that the attraction per unit current between a pair of coils of radii A and a, placed at a distance A/2 apart, was proved to be approximately $6\pi^2(\frac{4}{5})^{\frac{1}{2}}a^2/A^2$ dynes. (In § 49 the π^2 has been omitted by a clerical error.) If there are n turns on the fixed coil and n' on the moveable coil, the force is

$$F = i^2\, 6\pi^2(\tfrac{4}{5})^{\frac{1}{2}}\, n\, n'\, a^2/A^2.$$

$$= h\, i^2\, n\, n'\, a^2/A^2, \text{ say.}$$

Also if β be the ratio of the galvanometer constants for the fixed and suspended coils, we have by § 29 $\beta = n\, a/n'\, A$, approximately, so that $a^2/A^2 = \beta^2\, n'^2/n^2$.

Thus we have $\quad \text{Force} = h\, \beta^2\, i^2\, n'^3/n.$

$$\therefore \text{ current} = \beta^{-1}\, h^{-\frac{1}{2}}\, n^{\frac{1}{2}}\, n'^{-\frac{1}{2}}\, (\text{force})^{\frac{1}{2}}.$$

Thus an error in n', the number of windings on the suspended coil produces in the final value of the current three times the effect of an error proportionally the same in the value of n. A defect in the insulation of one turn of wire from the next, causing one or more turns to be practically short-circuited, produces the same effect as a diminution in the number of turns. Hence the insulation of the wire must be very carefully seen to.

Lord Rayleigh found that the coils of the electro-dynamometer were well insulated from the brass frame on which they were wound, but he does not record any experiments made to test directly the insulation of the turns of wire one from the other. An indirect test was obtained by the comparison of the galvanometer constant of each of the fixed coils with that of the suspended coil. The two numbers obtained were 2·60067 and 2·60072. Since the mean radii and dimensions of the sections of the two fixed coils are very nearly identical this furnishes a proof that the insulation from turn to turn is good.

The suspended coil gave rise to much more trouble. Careful measurements were taken during the winding of the coil, but the galvanometer constant deduced from them agreed very badly with that found by comparison with the coils of the electro-dynamometer. This gave rise to the suspicion that several turns were short-circuited by a false contact. To put the matter to a further test Lord Rayleigh wound a second coil of the same dimensions with the same number of turns of wire. The two coils were placed co-axally close together, and so connected in series that a current would flow in opposite directions in the two coils. The circuit was completed by a galvanometer of long period. Under these circumstances when one pole of a very long steel magnet is thrust suddenly through the opening, there should be no effect upon the galvanometer if the insulation is good; but if any of the turns of one of the coils are short-circuited, the other coil will of course have the advantage, and the galvanometer will indicate a current in the corresponding direction. It was found in fact that the second coil preponderated, and that 13 turns had to be put upon the first coil to obtain a balance. "With proper precautions this method of testing seems satisfactory, being approximately independent of the mean radii of the coils compared." A second test by a different method made by Mr. Glazebrook led to the same conclusion, viz., that the insulation was defective. The coil was accordingly unwound, and then several bad places in the wire were detected.

The ring was wound with fresh wire and its insulation tested by a very delicate method devised by Lord Rayleigh for this purpose. Four similar coils of fine wire, wound upon wood and of the same mean diameter as the ebonite "suspended" coil, were arranged so as to form a Hughes' Induction Balance.* If the distances of the four coils are adjusted by screw motions to an exact balance so that no sound is audible in the telephone, the introduction of a tertiary circuit between one primary and secondary causes a revival of sound whose intensity depends upon the conductivity, &c., of the tertiary circuit. A single circlet of copper wire ·004 inch in diameter gives a very distinct sound. When the ebonite coil, with its ends unconnected, is introduced, the sound is audible, but much less than that from the fine copper circlet. "Part of this effect may be attributed to its finite capacity as a condenser, in virtue of which sound might be heard in any case; but it is probable that the insulation is, in reality, somewhat imperfect. The closing of the circuit through a megohm gives a distinct augmentation of sound; and thus it is evident that the insulation, if not perfect, is at any rate abundantly sufficient for the purposes of the present investigation."

ERRATUM.—In the last equation of § 49 insert π^2 on the right-hand side.

(*To be continued.*)

* In this method only the *relative* values of the resistances are required. The comparison is entirely unaffected by any uncertainties in the value of the ohm.

* S. P. Thompson. "Elementary Lessons on Electricity and Magnetism," § 438.

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AN IMPROVEMENT IN THE METHODS OF INDUSTRIAL ELECTROLYSIS.

Of late years that branch of electro metallurgy which is concerned with the smelting of metallic ores by means of the heat generated between electrodes placed in opposing position after the manner of those in an arc light has developed with far greater rapidity than its elder brother, the electrolysis of aqueous solutions. On the one side is the Cowles furnace and its many derivatives and congeners, and on the other the best that can be mentioned is the Elmore process. It is true that various methods for manufacturing aluminium and producing sodium and magnesium, which involve definite electrolytical decompositions, and more than one process for the manufacture of "heavy chemicals," such as bleaching powder and caustic soda, have been recently attempted or realised; but the former depend largely on the mere heating effect of the current, and the latter are at present in a somewhat provisional stage, and in consequence cannot be reckoned among substantial industrial advances of electrolysis proper.

A consideration of the principles involved in the reduction of metals by some form of electric furnace, and in the electrolysis of a compound of the metal to be reduced in a state of aqueous or igneous fusion, respectively, leads irresistibly to the conclusion that the present preponderance of the former method is in a sense fortuitous, and is unlikely to be permanent.

The beautiful selective action of a current when applied under proper control to the work of electrolysis must always be a factor of importance wherever the maintenance of a reaction between comparatively narrow limits, or the obtainment of a product of a definite degree of purity, is a matter of concern. The possibilities of advance in technical operations are well foreshadowed by what has been already done in the domain of analytical chemistry to evolve electrolytical methods of general applicability from a few specific instances where the principle of electrolytic separation had found an isolated sphere of utility.

When primary batteries were the only practicable source of electricity, a few far-seeing inventors applied themselves to the problem of producing some substance of commercial value as a bye-product, the price of which should go to reduce the cost of generating current from that extremely expensive fuel, zinc. The artificial difference between the value of any given commodity in terms of energy and money made the realisation of this design perfectly possible. Up to the present, however, it has not been achieved, probably because of the limited range of marketable materials that can be thus produced, the expense that would be involved in their collection, and, above all, because of the banishment of the primary battery, for all but special purposes, as a source of current, by the evolution, now almost complete, of the dynamo. Although the application of this idea to the primary battery is obsolete, yet the idea itself is by no means necessarily worn out and valueless. It merely needs adaptation to an altered environment to develop from its encysted state and become active and fruitful.

The deposition of a metal from a solution of one of its salts by the passage of a current is a remarkably simple operation on paper, but is apt to prove troublesome if attempted without a complete knowledge of the best conditions under which to work. Even when a metal like copper is taken as an instance, the deposition of which has been practised on a large scale for years, difficulties at once arise when so elementary a feat as the production of an unusually thick sheet has to be accomplished. In this and similar instances much can be learnt from what is already actually done in the laboratory for the purpose of analytical separation. The direction in which advance is possible was recently clearly indicated in a Paper read before the German Society of Applied Chemistry, by Dr. W. Borchers, who laid particular stress upon the necessity for seeking guidance from the store of information that has been accumulated primarily for the benefit of the analyst. It is obvious that the electrolytic separation of a metal from an aqueous solution of one of its salts is much aided by the exclusion of strong acids in the free state, as they tend if present to undo the work of electrolysis by redissolving it. Further, equal care is necessary to get the utmost advantage of that portion of the energy consumed which would, under primitive conditions, be expended in the liberation of oxygen at the anode. Of course, when the sole function of the current is to transfer metal from a crude anode to a pure cathode, as in copper refining, the question does not arise; but when an insoluble anode is used, and the metal is reduced in the same positive sense as in ordinary methods of smelting, the utilisation of the oxygen or potential oxygen becomes a matter of serious concern. The best plan would appear to be to provide some substance at the anode, the oxidation of which would yield a product of commercial value. In analytical chemistry the first condition is fulfilled by transforming the metallic salts of the strong mineral acids into those containing comparatively weak organic acids, and for this purpose the oxalates, tartrates, citrates, benzoates and cyanides are freely used. The products of the oxidation of these, as far as their commercial value is concerned, are naturally a matter of indifference to the analyst. To the industrial chemist, however, the first cost of the salts in question, and the value of the substances formed by their oxidation, are of the greatest moment, and of those named, none offers him the smallest chance of profit. The most likely substances to prove remunerative are various members of the series of bodies obtained by the distillation of coal tar, especially as among them are several natural groups of bodies of immediate industrial significance. Prominent among these are the cresols, a group of three bodies belonging to the class of substances known as phenols, the first member of which is more familiar under the title of carbolic acid. The fact that they are insoluble in water does not prevent their use, as they are readily soluble in solutions of caustic alkalies, and should an alkaline electrolyte be inadmissible, they may be readily converted into their sulphonic acids, and these, or their salts (sulphonates), possess two properties which render them well suited for electrolytic purposes, viz., ready solubility and good conductivity. As the products of their systematic oxidation include such substances as the oxybenzoic acids, and some of the quinones, there should be little difficulty in turning them to account. In the formation of such substances the ease with which reactions are controlled, to which we have already alluded as one of the most striking advantages of electrolytical operations, could be utilised to the full in securing the production of the maximum quantity of the most valuable substance, greater commercial efficiency than can be secured when the reactions are brought about by purely chemical means being thus possible. In addition to this the use of costly special oxidising agents each adapted for one reaction or group of reactions to the exclusion of others chemically dissimilar, could be done away with, reliance being placed on the regulation of the conditions under which the current was allowed to act.

By the adoption of the principle that it is almost as easy to turn out valuable bye-products simultaneously with the production of the material for obtaining which the installation was primarily intended, there is little doubt but that many enterprises whose prospects, as long as they stick to the groove of manufacturing routine, can be moderate at best, might find a field that would well pay for the reaping. It might even come about, as has already happened in more than one branch of industry, that the bye-product and the main-product changed places in order of importance.

OIL AS AN INSULATOR.

The following is the authorised abstract of the interesting discussion on Prof. Hughes' Paper on this subject, which took place at the Institution of Electrical Engineers, on Thursday, the 17th inst.:—

Mr. CAMPBELL SWINTON had made some experiments on the difference of sparking distance in air and in oils; his results did not agree with those of Prof. Hughes', but made oil much worse. He used as a source of E.M.F. an induction coil capable of giving a 7″ spark in air, the distance he found from one to three times as long in air as in oil. Possibly his oils were not of so good a quality as Prof. Hughes'. He would like to know if Prof. Hughes dried his oil. He had tried doing this, but found that after drying it would re-absorb water, and, therefore, preferred tests on undried

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samples as being of more practical value. When using paraffin oil he found a distinct deposit of carbon at each discharge.

Mr. JOHNSON (of Johnson and Phillips) rather objected to the alleged anticipation of Brooke's system. Prof. Hughes' system was one with an insulated pipe (gutta-percha, &c.). Mr. Willoughby Smith had tried it and found it of little use. He objected also to the idea of the oil closing up faults in the gutta-percha covering of a cable on the same principle that it was bad to use tarred yarn on gutta-percha core; it temporarily closed incipient faults and thus prevented their detection. His firm had a line laid at their works on the Brookes' system, which had been repeatedly tested at 15,000 volts, and had stood it perfectly. There was a great difficulty in getting the right quality of oil. The best method of testing, he thought, was to pass it all through a narrow orifice and test it electrically as it passed.

Mr. GRAY called attention to a Paper by Rousseau in (?) 1826, on the insulation resistance of oils. He himself had made some tests on specific resistance by direct deflection with 100 cells, his results were as follows:—In C.-G.-S. units, 10^{20}; rape oil, ·5 to 5; lard oil, 2 2 to 5; colza, 1 to 15; cotton seed oil, 53; and linseed ·31 to ·8; he then measured the spark distance with 10,000 volts, and took the resistance again, which was always less than before with vegetable oils and paraffin. With thick resin oil he found when the electrodes approached to such a distance that 10,000 volts once gave a spark, that 2,000 volts would then give a spark through the same distance. Having measured some resin oil in 1887 with 100 cells he found in 1889 a higher specific resistance with 25 cells, but a lower one when measured with 100 cells as before.

Mr. VARLEY preferred to test the air and oil in series, instead of parallel, as Prof. Hughes did, *i.e.*, he put one electrode under oil, and the other some distance above it. He had tried to make a condenser with three thicknesses of bank-post paper between the plates, immersing it in dried paraffin, but it broke down at from 300 to 400 volts.

Dr. FLEMING said that no one need be afraid of putting transformers in oil, as Ruhmkorf had used it for insulating his coils in 1851. A description was also given by M. Gine, in 1854, of a coil wound in cotton-covered wire, which was desiccated in vacuo and then kept under turpentine oil—from this he got a 12″ spark. A Paper by Poggendorf on the same subject would be found in *Phil. Mag.*, July, 1855, using vegetable oil or oil of turpentine. He would suggest, on the analogy of alloys having a higher specific resistance than pure metal, that perhaps some mixture of two or more oils might be found which would give higher insulation than pure ones.

Mr. DONOVAN asked why the Post Office did not take up oil insulators, and wished to know how many miles of oil-insulated cable were now in use. He said that if vegetable oil were mixed with paraffin the latter would evaporate and leave the vegetable oil behind.

Mr. CUTHBERT HALL had found that the temperature co-efficient of oils was very high, the resistance varying as much as 20 per cent. between 16 degrees and 24 degrees. The best insulating oil he considered to be half of "first run" oil and half of solid resin. He had found jute to be a very good insulator; the insulation of a dry jute-covered cable was actually lowered by impregnation with oil. Transformers he preferred to slowly heat up to a high temperature and then immerse in resin oil. He confirmed Mr. Gray's experience of continuous sparking in paraffin when the first spark had passed, but resin oil did not behave in the same way.

The PRESIDENT said there had been a good deal of loose expression with regard to the resistance of the various oils. "High resistance" had been used by different speakers to mean (1st) actual high specific resistance in the same way that one speaks of the specific resistance of a metal; (2nd) high resistance to a spark passing through the mass of the oil; and (3rd) high resistance of the surface of the film. Which of these was Mr. Hall referring to when he mentioned the high temperature coefficient?

Mr. HALL said he measured the actual resistance between two metal plates wholly immersed in the oil, and therefore referred to the first meaning.

Mr. KAPP said the first transformer he tried to insulate with oil broke down in two or three minutes. It was wound with silk-covered wire. He then had the coil unwound and the wire rewound after, passing through a bath of boiling paraffin on its way to the winder. The transformer then ran with 17,000 volts, and had never broken down again.

Mr. TROTTER asked what was the real weak point in an oil cable. Was it the oil itself or was it the solid insulator, hemp, paper, or gutta-percha?

Prof. FORBES said that just at first cables were insulated with gutta-percha, as at Paddington. This was soon given up, because the wires were run so hot that the gutta-percha got very soft. To-day, however, cables were never run hot, and he thought it quite possible that gutta-percha might be tried again with good results. He also thought that something should be done to try and improve gutta-percha by treatment with oil.

Mr. PREECE said Mr. Donovan had asked why the General Post Office did not use oil insulators and Brookes' cables. The objections to the former in England were that the rain got under the oil (light oil having been used in those he tried), that the wind blew the oil out, and that spiders could not be kept from spinning their webs over them. He had been much impressed with Mr. Brookes' system when he first saw it, and had a 40-wire line put down from Vauxhall to Clapham Junction. They had considerable trouble at first with bad joints in the tubes, but even when these were put right the water got in when they were using light oils, of which very large quantities were lost. He then got some special heavy oil from America, but could not get it to run far along the pipes. However, the wires still tested well, even when the oil had leaked away, and they were only separated by impregnated cotton or hemp, say 1 megohm per mile. This was quite good enough for practical work, and was steady, and a great improvement over an air line, which might test 100,000 ohms a mile one day and as many megohms on others.

Mr. SWINBURNE said the "healing" property of oil insulation did not exist for transformers. When a coil once sparked across it was ruined. In a transformer there were many H.P. behind the spark, and when it passed an arc at once followed it. He had tried drying the oil chemically in various ways, but had found it quite useless. The real insulator he considered to be dry cellulose, the oil merely keeping the moisture out. Perfectly dry cotton, even when thoroughly saturated with oil, will get moisture from the atmosphere if exposed to it for a short time. When jointing impregnated cables three or four feet should be cut off each of the ends, and the joint made at once. The oil for insulating transformers must be heavier than water, or moisture will get down, and if it touches the covering of the wire at any point it will spread all over it.

Mr. JOHNSON, referring to Mr. Preece's remarks about oil insulators, said that in the line on which they were tried by the Post Office he himself had counted some six or seven common shackle insulators, and that the end of the line was connected to a quarter of a mile of old gutta-percha cable in an underground pipe. This, he thought, was quite enough to account for the poor results obtained.

Prof. HUGHES, in reply, said that the high results which he gave were the best he could get. The very high ones were for sparking distance with the "impulsive rush," working with Leyden jars. He found the resin oil of to-day not nearly so good as that which he used in his earlier experiments. With regard to the Brookes system, he liked Mr. Brookes when he brought his system over, and said nothing about his own previous work in the same direction. He noticed, however, that Mr. Brookes had disclaimed a good many things in his patents, and now relied principally on the use of stand pipes and on heating the oil. In reply to Mr. Trotter he never found any covering equal to gutta-percha in resistance. He agreed with Prof. Forbes that gutta-percha might be much improved by oil treatment.

Mr. CAMPBELL SWINTON, referring to Mr. Swinburne's remarks, pointed out that Mr. Tesla said his transformer constantly broke down and "healed" itself.

Mr. SWINBURNE replied that Mr. Tesla was only dealing with infinitesimal currents and small power. In an ordinary commercial transformer the fact was as he had stated—there was no healing power.

PHYSICAL SOCIETY.

At the usual fortnightly meeting of this Society on March 11, 1892 (Prof. A. W. Rücker, F.R.S., Vice-President, in the chair), Mr. H. M. ELDER, M.A., read a Paper

"On a Thermodynamical View of the Action of Light on Silver Chloride."

In the decomposition of silver chloride by light chlorine is given off, and a coloured solid body of unknown composition (sometimes called "photochloride") formed, the reaction being indicated by the formula $n\,AgCl = Ag_n\,Cl_{n-1} + \frac{1}{2}\,Cl_2$. If the experiment be carried out in a sealed vacuum the chloride is darkened up to a certain point, but regains whiteness when left in the dark. These facts have led the author to believe that the pressure of the liberated chlorine is a function of the illumination or intensity of light falling upon the chloride in the same way as the pressure of a saturated vapour is a function of the temperature. Since illumination is a quantity in many respects analogous to temperature he considers it not unreasonable to apply thermodynamic arguments and regard chlorine in presence of silver chloride and "photochloride" as the working substance in a "*light engine.*" He therefore supposes a Carnot's cycle to be performed on the substances at constant temperature, the variables being pressure, volume, and illumination.

A Paper

"On Choking Coils"

was read by Prof. PERRY, F.R.S. Regarding a choking coil as a transformer with one primary and many secondaries represented by the conducting masses, he pointed out that all the secondaries might be replaced by a single coil of n turns and resistance r ohms, short-circuited on itself. Assuming no magnetic leakage the equations for the two circuits at any instant are $V = RC + N\dot{\theta}I$ and $0 = rc + n\dot{\theta}I$, where N and n are the turns R and r the resistances, I the total induction in 10^8C.-G.-S. lines, &c., and C and c the primary and secondary currents respectively, $\dot{\theta}$ standing for d/dt. Since the exciting current C is all important in choking coils, and its value depends on the law of magnetisation, the equations are treated in a different manner to that adopted in ordinary transformer calculations. Expressing the cyclic magnetic law in a double Fourier series the value of A (viz., $NC + nc$) is deduced, and when V or I is given as a periodic function of the time, C may be calculated. Assuming $V = V_0 \sin kt$ the author finds

$$C = \frac{V_0}{N^2 \sigma k}\left[\sqrt{1 + 2e\sin f + e^2}\cdot\sin\left\{kt - 90 + \tan^{-1}\left(\tan f + \frac{e}{\cos f}\right)\right\} - b\cos 3kt - m\cos 5kt\right],$$

where $e = n^2\sigma k/r$ being the eddy-current term, f is the hysteresis term, and b and m constants depending on the law of magnetisa-

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tion. For ordinary transformer magnetisations $b=0{\cdot}2$ and $m=0{\cdot}05$. From the above expression it will be seen that if there is no hysteresis (*i.e.*, $f=0$), the effect of the eddy currents e is to increase the amplitude of the important term and to produce a lead of $90° - \cot^{-1} c$, whereas the effect of hysteresis without eddy currents is to leave the amplitude unaltered and produce a lead f. Putting $f=0$ gives results in accordance with experimental observation, hence the author is inclined to believe that there is no hysteresis in transformers. He also points out that the higher harmonics must exist, and shows that a choking coil with finely divided iron may prove a method of increasing frequency by mere magnetic means.

Taking the case of a 1,500-watt transformer (2,000 volts) unloaded, in which the loss in eddies was 40 watts, it is shown that a secondary of two turns and resistance 1·9 ohms could replace the eddy current circuits. Assuming constant permeability and no eddy currents, the value of C comes out $0{\cdot}07398 \sin (kt - 90°)$, whilst with eddy currents and some saturation but no hysteresis $C = 0{\cdot}07911 \sin (kt - 69°{\cdot}2) - 0{\cdot}0148 \cos 3kt - 0{\cdot}0037 \cos 5kt$.

Dr. FLEMING said he was working on the subject of choking coils, and had found that in closed circuit transformers unloaded, the real watts were about 0·7 times the apparent watts. This, on the assumption of sine functions, would indicate a lag of about 45°. A similar rule for open-circuit transformers was much needed. It was important to know what size of core and coil was required to choke down to a given current.

Dr. SUMPNER thought it better to treat the subject graphically rather than by analysis, and described a construction whereby the fundamental equations could be readily integrated.

Prof. PERRY said he had reason to think that ordinary hysteresis curves were not applicable to transformers unless one knew the cyclic curves it was impossible to work graphically. By analysis of the experimental E.M.F. and current curves, one could work backwards and find the true magnetisation curves.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—TUESDAY, MARCH 22ND.

NEW TELEPHONE COMPANY BILL.

On the motion for the second reading of this Bill,

Sir J. FERGUSSON said: I think the House will perhaps allow me to state the course which the Government find it necessary to take with regard to this Bill, and incidentally the policy which they intend to pursue regarding the very important questions concerning the telephone system. The Bill now before the House is in itself moderate in character. It really seeks to obtain for the New Telephone Company statutory powers similar to those provided for the Post Office by the Act of 1863, except in one particular. I do not know that the powers asked would be excessive if it were desired by Parliament that private telephone companies should be placed in possession of separate statutory powers. That has never hitherto been the case. But the telephone interest is in a very different position to that of gas, electric lighting, water companies, and so forth, because none of these touch or trench upon the perrogative of the Crown; but it has been decided by the High Court of Justice that telephones are telegraphs, and consequently are the monopoly of the Post Office. Accordingly, no separate powers have ever been conferred upon telephone companies, but they have carried on their proceedings under licence from the Postmaster-General. I need not trouble the House with the whole history of the telephone question. The House is familiar with it, and only a few years ago it was the subject of inquiry before a Select Committee. Still I should like to remind the House that the policy pursued by my predecessors, to whatever party they belonged, was to grant licences to commercial companies for the erection and maintenance of telephones. These licences, at first restricted, were afterwards made universal, and, in fact, 13 companies were granted powers extending over the whole kingdom. It was intended by my predecessors that there should be thus commercial freedom, and that the public might be efficiently served by the competitive efforts of these companies. The result cannot be said to have been wholly satisfactory, for gradually these companies have been nearly all amalgamated or absorbed by one large company, the National Telephone Company, which has made greater advances than any other undertaking of the kind in this country. There are, however, some absorbed in a smaller group, headed by the New Telephone Company, by whom the present Bill is promoted. There have been many representations of late made by important public bodies of the inadequacy of the present telephone system. Only yesterday I had a very large deputation from the London Chamber of Commerce, who represented that it was very desirable—in fact, that it was really important—that Her Majesty's Government should bring in a general powers Bill, so as to afford facilities for the development of the telephone, not only in the metropolis, but also with regard to inter-town service all over the country. In view of what I believe to be the very prevalent opinion, and of the constant policy of the Post Office, it will be my duty on the part of the Government to oppose the second reading of this Bill, and *a fortiori* of the Bill promoted by the National Telephone Company, which is not at this moment before the House, but which has been read a first time, and which seeks powers much wider than have ever been asked by the Post Office. The fact is that owing to the failure of the intentions of the Government the telephone system has made less progress in this country than perhaps in any other country in Europe. Whereas in France and Germany it has made very great strides, so that a considerable percentage of the people are users of the telephone, in England a very small fractional portion only enjoy the use of these facilities. In London, the largest city in the world, not one fourth the number of persons are users of the telephone that there are in the City of Berlin. The form of licence issued by the Post Office has something to do with the hindrance to the development of the system. The licences confine the companies in their operations. They, for instance, restrict them from delivering messages, which is the process followed in France, where the telephones belong to the Government, and they cannot communicate with the Post Office except under considerable charges. They cannot make their lines along railways, roads, and canals, where the Post Office have the entire concession, without paying a very heavy wayleave. Ever since I have occupied my present office I have given my earnest attention to this subject with a view to devise a system which would facilitate instead of restraining the development of the telephone industry, and at the same time would sufficiently guard the Post Office monopoly, which, though an ugly word, really means guarding the interests which the public have acquired. I do not think that these two objects are at all incompatible, and it has been our desire to frame a scheme by which the greatest encouragement should be given to the development of the telephones, and that the Post Office should work entirely in alliance with them. That there is a real danger of the valuable telegraph property being injured by the telephones without due provision I can prove by the fact that, wherever the telephone system has been effectually developed, there the growth of the telegraph revenue has been checked. The telephone system has been more considerably developed between the large towns in Lancashire and Yorkshire than perhaps anywhere else; but in whatever part of the country it has been developed, there the growth of the telegraph revenue has been checked. But the concessions which might be made to the telephone companies mainly consist of these:—In the first place, messages might be transmitted from the telephones and communicated to the public telegraph wires, so that there might be free communication between the two. Messages might be sent from any telephone subscriber to be delivered to his correspondent. At present that cannot be done. Messages might be sent by post as letters, and they should receive the service of the express messengers. No charge shall be made in the post-office for the work of taking down telephonic messages and despatching them by telegraph or by post, and the wayleave now charged over railways shall be reduced from 20s. per mile per year to a nominal sum. And, lastly, the companies shall be allowed to establish call offices in post offices were possible. There are other possible concessions which, in the public interest, the Government are prepared to make while adequately securing the telegraphs, but they are mere matters of detail. Then, also, the Government are prepared to facilitate legislation giving certain moderate powers for the construction of telegraphs by their licensees. These concessions, if granted without corresponding provisions for the protection of the public revenue, would be very dangerous; for if the telephone companies were in communication with all the large towns, and sent messages all over the country, undoubtedly the system would to a large extent supersede the use of the telegraph, and consequently largely diminish the telegraph revenue. Therefore, it is an essential feature in the scheme, if carried out, that the Government should have possession of the trunk wires. It is our view that we ought not to interfere with the commercial business of the companies in establishing exchanges as widely as possible wherever their enterprise may lead them, but that the junction of those exchanges should be in the hands of the Government. The trunk wires should be in the hands of the Government in order that the public may have their portion of the sum paid for the message, in the same way as telegrams; but that would be fixed at a moderate rate, so as not to check the development of the telephone. As regards main lines in towns connected with several exchanges, it is desirable that they should be in the hands of the Post Office, because if telephone companies become largely developed there will come to be an infinity of thick cable wires connecting these exchanges, and, as in New York, the time may come when these might be inconveniently multiplied to the public danger; and the local authority, as in New York, might be compelled, at immense expense, to remove them from overhead and place them underground. If the rival telephone companies were to be possessed of the power of operating in the same towns or area, or possessed powers to take up the public streets and lay down underground wires, there would be infinite confusion and disturbance of traffic, and private rights might be encroached upon. But if the Post Office has power to make the main connections, they could lay wires side by side to accommodate all the different exchanges—the exchanges running separate wires for their own service; and so the work would be done with the least possible disturbance, and it would increase the accommodation to the public. But any such powers would be naturally viewed with great jealousy were they not exercised in strict harmony with the local authorities; and it is the intention of Her Majesty's Government, both in the additional powers they propose to confer and the additional powers which they propose to seek from the House, to carry the local authorities with them throughout. Another question is, How far is this extension of licences to proceed? It is contrary to sound policy that licences should be given to men of straw, who merely acquire them for the purpose of selling them and for levying blackmail, in a sense, upon existing companies and solid organisations; and, therefore, the view of the Government is that fresh licences should not be given all over the country. That almost follows on the desire of the Government to possess the trunk wires. Wherever the Local Authority are satisfied that a telephone exchange is desirable in their area, and the Government are satisfied that the licensees are in a position to carry out their undertaking, and that it is in the public interest desirable that they should have a licence, then they will be granted a licence for that area. It

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is my intention on the part of the Government to move in a few days for leave to bring in a Bill to confer additional powers on the Post Office in regard to telegraphs and telephones. It would be improper for me now to indicate what those powers will be. They will be very moderate, and will not infringe any private rights, and in every case we shall carry the local authority with us everywhere. There will be a slight extension of existing powers where they are insufficient for the development either of this new modern enterprise, or of small extensions of telegraphs where public necessity requires. It is extraordinary how local authorities and private individuals can interrupt the making of most moderate extensions for months. I do not think I need go further into the matter just now, but I do not think the House will be prepared to establish private companies in so strong a position in opposition to Government telegraphs as would be created by this Bill; and I move, as a matter of form, that the Bill be read a second time this day six months, though I have every reason to believe that the promoters do not intend to press it in view of the statement I have made.

Mr. CALDWELL, in view of the announcement that the Government intended to introduce a Bill in a few days, moved the adjournment of the debate.

After a short discussion the debate was adjourned to that day week.

LEGAL INTELLIGENCE.

Lane Fox v. Kensington and Knightsbridge Electric Lighting Company (Limited).

MONDAY, MARCH 14TH.

Sir HENRY C. MANCE, examined by Mr. R. W. WALLACE, said that in the year 1878 the term "earth" meant a vast globe or reservoir, a common reservoir, the resistance offered to the passage of a current being practically nothing. Reading Lane Fox's specification as an engineer, he would have used the ordinary earth that a telegraphist would have used.

Mr. JUSTICE SMITH: What is the good of going over this again and again and again? I have had this dozens of times—all the same thing. I will tell you my own view at once about "the earth." It seems to me, subject to what I may hear in the speeches, that "the earth" means any return, but it is liable to be altered by the context in which it is used. It seems to me the number of eminent gentlemen who have been called agree that "the earth" meant any return, call it soil, or insulated or uninsulated wires, but is liable to be controlled by the context it is used in, in the specification, and that is for me. That is the sole point on that.

Cross-examined by Mr. MOULTON, WITNESS said that a conductor would answer the same purpose as the soil if it had resistance in it.

Mr. JUSTICE SMITH: Before the distribution of currents came in they had one current that used to go through all the lamps in line.—No, my lord, you will find a description of the multiple arc system before 1878.

Mr. HERBERT W. MILLER, examined by Mr. FINLAY, said that he was the resident engineer at the Kensington Court Station of the defendant Company. He first became connected with the Company in 1885. Before 1886 he was at Crompton and Co.'s works. He did not know of any installation where the system described in the plaintiff's specification was used. He did not think it was possible to work with that specification at all. The principal reason was that in the specification it was taken for granted that the accumulators were automatic regulators—that was to say, that they could be charged and discharged by increasing or decreasing the E.M.F. to a very small extent. He believed that it was absolutely impossible to send back large currents such as would be used in the central station through the earth. It was absolutely impossible either to charge or discharge the battery with a small increase or decrease in the pressure.

Mr. JUSTICE SMITH: That is the whole question—what do you mean by "small"?—I think it is absolutely impossible to charge a battery properly under from 15 to 20 per cent. rise in the pressure. In ordinary practice it is 25 per cent. As a general rule they started about 11 o'clock in the morning to charge the secondary batteries at Kensington Court. Witness then described by means of curves the process of charging the batteries. By working the dynamo to produce 115 volts, it took from 12.2 midday to 4 o'clock to get the pressure in the batteries up to 113½. The current at 4 o'clock was 70 amperes. It would then be necessary either to raise the pressure above the 115 or to keep charging at that low rate.

Mr. JUSTICE SMITH: And if you kept your charging at this very low rate, what then?—It would take you too long to get the batteries full. It would take about 10 hours longer.

Mr. FINLAY: The difficulty would not be avoided by increasing the area of the battery plates.—Witness did not think that at all possible. The pressure in the cell when charging being due to chemical action, it would be the same whether the cell was large or small. In a cell there was the internal resistance, and the resistance of the chemical action which was the result of the transmission of the electric force into it. The resistance of the cell would be diminished by increasing the size—the area, but the resistance due to the chemical action would not. They had an arrangement of switches, so that when the pressure of the cells rose they were able to move the switches with which the feeder was connected down to a cell where the pressure was at a normal amount. When the pressure dropped they were able to move the switch so as to introduce more cells, and thus keep up the voltage, and they continued charging the batteries until the reading of the meter in ampere hours showed them that the batteries were full. They used the same meter for the discharge.

Mr. JUSTICE SMITH: What is the meaning of an ampere hour? Supposing a man said 20 ampere hours, what does it mean?

Mr. FINLAY: It would mean that he could get 20 amperes for one hour, or one ampere for 20 hours.

WITNESS, continuing, said that the capacity of each of the batteries was 1,000 ampere hours. And the meter showed when they were full the bubbling really was going on the whole time of charging, but it began to bubble freely when it was about two-thirds to three-quarters full. It would not do to stop at that point. The battery would not be full up. The next time they tried to discharge the battery they would not get the full amount out of it, and it would be gradually decreasing each day. If they only put 600 amperes hours into the battery, they would be only able to take out about 500. If they only put into the battery each day exactly what they took out the capacity of the battery would gradually diminish, because of the loss which took place between each charge and discharge. Cells joined in connection with the mains on which the lamps were as proposed in Lane Fox's specification, would not regulate the pressure. If the batteries were supposed to be acting as regulators, and a number of lamps were turned off from the circuit, the extra current produced by turning out the lamps would go into the battery, and the fact of going into the battery would at once cause the pressure to rise. In the same way, if a large number of lamps were constantly lighted, and the current required for these lamps was taken out of the battery, the pressure would at once fall in the battery.

Mr. MOULTON: I think that is an admission of our whole contention?—In order to get over these defects, there not being automatic regulators ——

Mr. FINLAY: What would have been the effect of these changes you have been describing in the mains with which the lamps were in connection?—The pressure would be varying up and down continuously.

Mr. JUSTICE SMITH: What do you say the batteries do?—I say the batteries do not automatically regulate the pressure.

Mr. FINLAY: What is the use of the batteries? What do you use them for?—As reservoirs of electricity to be used during the time that we do not require to run the machinery.

How, in fact, do you regulate at Kensington Court Station?—We regulate by altering the speed of the engines and dynamos on the indication afforded by the voltmeter showing the pressure at the point where each feeder enters the mains.

Referring to the process of charging, WITNESS said they finished charging at the Queen's Gate Station about four o'clock to half past four; at the Kensington Court Station at about nine o'clock at night. The Queen's Gate Station was charged through the charging main. After half-past 11 the whole of the work was done from the accumulators themselves, the dynamos being stopped. They had to move the accumulator switches from five to six times between 11.30 and 7 a.m. They had to move the switch first of all five or six times to make the battery take up the whole of the work previously done by the dynamos. After that it was necessary to move the switch two or three times, as the lights are turned off before the station was shut up at about half-past 12 at night.

Cross-examined by Mr. MOULTON, witness said the current would not flow out of the batteries unless there was a tremendous difference in pressure; small variations would not be taken up by the accumulators. It was not true that if one crammed current in at a great rate, there was a very much greater resistance in the batteries, and they had to charge at a higher pressure. They could send 200 amperes through at practically the same pressure that they could send 20. They had a counting-meter, which also showed them the way the current was going. They had an ammeter on the batteries fixed in circuit. At one time they had the charging switch and discharging switch combined—one switch to do the two operations. They made the change some time in 1890, about October. At Kensington Station they found it very much more convenient to have both switches entirely independent, but at Queen's Gate there was no necessity to alter it.

Re-examined by Mr. FINLAY, WITNESS explained that he meant the difference in pressure required to put 20 amperes or 200 into a battery, when they had no internal resistance in the cell it was so slight it was practically the same pressure—it was so minute.

Mr. R. S. ERSKINE, examined by Mr. R. W. WALLACE, said he had been the Secretary of the defendant Company since soon after its formation. He went into the service of the Brush Company in 1881, either at the end of April or the beginning of May. Mr. Lane Fox was with the Brush Company at that time, and he took witness into his department. He remembered the exhibit that was prepared for the Paris Exhibition. The fittings were only wired with one wire, the fitting itself forming the return. At the Crystal Palace Exhibition in 1882 no batteries were used in Mr. Lane Fox's exhibit. He had something to do with the arrangement of the plant at the exhibition at 108, Queen's Gate. The batteries were used there to aid the dynamo. He was assistant engineer at the Vienna Opera House. There were four sets of batteries of 50 cells each.

Mr. JAMES SWINBURNE was then called and examined by Mr. FINLAY. He said that with regard to what was done by the defendants and comparing it with what was described in the specification, and what was claimed by the plaintiff in his specification, the points of resemblance were in using generating and consuming devices in parallel. The points of difference were in the way these were used. Mr. Lane Fox thought he would save half the drop of potential in the leads by the use of the earth. Next he proposed to place the batteries, dotted about the system, instead of at the generators. He proposed to run a practically constant current from the station. The defendants used switches in order to enable them to charge or discharge their batteries, whereas Mr. Lane Fox thought that the batteries would charge or discharge with a practically small variation. Reading from the specification, page 5, "When the electromotive force falls owing to the draught from the mains when the force is most used and needed," witness reminded the Court that there was a regulator keeping the electromotive force constant at the engine, so that the electromotive force at the station could not fall. The electromotive force from different parts of the system would fall owing to the draught in the mains,

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The passage showed it was the fall due to the resistance in the mains that the patentee was considering. Quoting again from specification, page 5, line 3, "The number of cells in each of these batteries will depend on the electromotive force of the mains," witness said if the batteries there had not been dotted about all Mr. Lane Fox would have to do would have been to have said that 50 cells should be used. Mr. Lane Fox meant a different number of cells in different places. At line 16 he said, "Also a number of reservoir batteries as before explained," that meant dotted about as before; otherwise Mr. Lane Fox would have simply said, "Also a number of batteries." Assuming "the earth" to be an important part of the system, which it was, because Mr. Lane Fox wanted to get his electromotive force constant at each lamp, so that it should not vary; he wanted to reduce the variations by half by the use of the earth return, which he considered had no resistance. Witness proceeded to explain by aid of three diagrams the effect of dotting batteries about a system of electrical distribution. At the station in Case III. he assumed 100 volts kept constant by the regulator. There were 400 amperes coming from the station. Half-way along the pressure had fallen to 95 volts. It was charging a battery of 47 cells. 95 volts were going into the battery. 200 amperes were going into the battery with 47 cells. At the far end it had fallen to 90 volts, and there was a battery of 45 cells, also taking 200 amperes under 90 volts. Taking the same installation and putting a full load upon it, they got "Pressure fallen owing to draught in mains." There was still 100 volts kept constant by the regulator and still 400 amperes. There was a large number of lamps, and with varying voltages from 100 to 95 in the first half of the main. These just ran slowly down, taking 400 amperes. The middle battery at 94 volts discharged 200 amperes, and kept that level. Then further along there was another set of lamps taking 400 amperes, varying from 95 volts and running slowly down. At the far end there were the same cells, but they had now got 88 volts instead of 90, and they were discharging 200 amperes. The cells in this case, compared with Case II., reduced the variation in the lamps enormously. In fact, if that had worked it would have been a very clever invention. He did not, however, think that practically batteries could be worked in that way. In the first place, a battery would not charge and discharge usefully with such a small variation of pressure. He did not know whether it was a fair thing to say, but even if they did the batteries at that date were of no practical use.

Mr. JUSTICE SMITH: Not Planté's batteries?—Not the Planté of 1878, my lord.

Mr. JUSTICE SMITH: I thought that I had evidence that the batteries were good enough, only they did not know how to work them properly. Mr. Crompton said that.

The WITNESS: Might I suggest that there is a little confusion? I mean the Planté of 1878.

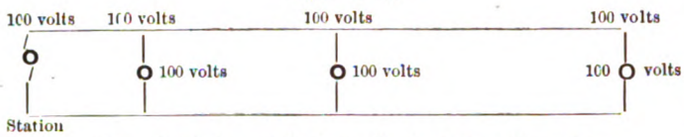
Mr. JUSTICE SMITH: Oh, no; Mr. Crompton was clear enough. Mr. Crompton's theory was that these batteries were all good, the whole lot of them—only he found out the way to work them, which nobody found out before. That was Mr. Crompton's evidence.

Continuing, WITNESS said a Planté cell would work as a regulator under certain conditions if they did not want it for storing, but not in the way described in the specification. He had heard it suggested in cross-examination that the cells might be kept in good condition by charging them up to fully bubbling point once a week or so, but did not think once a week was enough. He also heard the suggestions that had been made as to rendering it unnecessary to charge fully by increasing the size of the plate area. It was not a practicable way of overcoming the difficulty. In modern cells the resistance of the cells might be made as small as one pleased by increasing the surface of the cell, and it had been suggested from that that they could charge them with a slight balance of pressure. The resistance, however, was not the important quantity; it was the back pressure of the cells that they had to consider, and the back pressure of the cells went up to 2½ volts; that was so if they charged a cell, however large it might be. As to the Planté cells of 1878 they had a great deal of leakage. The result was that if one increased them one increased the amount of leakage. With regard to the plateau of which they had heard so much, witness said the charging and discharging curves did not correspond, and proceeded to explain it to Mr. Justice Smith as to the possibility of practically using earth-plates. He had tested an earth-plate, which he understood was put in the ground by Mr. Lane Fox in a garden at Teddington. He tested it recently, about four months ago. It was put there about 1884. It was about four feet by six. He put the dynamo straight on to it—short-circuited it, as it were, through the plate—using that as one plate and the water pipes as the other, with 60 volts, at all events, on the earth-plate itself. He got 20 amperes. There were no lamps at all. All the current that the dynamo generated went through the earth-plate. The dynamo was capable of generating a good deal more, but had not the chance. The current was simply dependent on the resistance of the earth-plate. Taking Lane Fox's, specification the earth-plates would have to be of a fabulous size. He did not want to make an absurd statement, but he had calculated from that that the plate would be somewhere between 26 acres and four square miles to take 1,000 amperes—it was really utterly ridiculous—with one volt at each earth-plate. He was aware that the specification referred to the possibility of using gas and water pipes as an advantageous connection with earth. It would not be practicable. The chief difficulty would be that wherever the soil was damp the pipes would be eaten away. It would not be a trifling matter. It was a matter which could be rigidly calculated, and for 1,000 amperes running continuously, day and night, you would eat away about 10 tons of pipes in a year. That 10 tons would not be spread over the whole installation. The total 10 tons would be chiefly concentrated at the damp places. It would therefore, eat the pipes into holes there. Explaining the function of the feeders in the defendants' system, the witness said the difficulty soon came up of the variations of pressure due to the resistance of the mains. To get over the loss of pressure due to the resistance of the mains, the use of feeders for carrying the current in at various points had been adopted. The feeders secured a constant pressure from place to place, as well as from time to time.

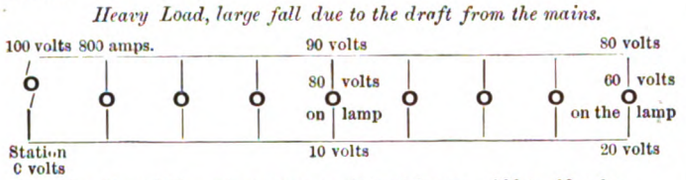
Cross-examined by Mr. MOULTON, Mr. SWINBURNE said any competent electrician reading the specification would know that the earth was being used as a very good conductor. If for any reason he did not want to use the earth he would use another conductor. Supposing there were telegraphs about and he was forbidden to use the earth, he would know that he could use an insulated conductor. He did not think any competent electrician would attempt to make an earth-plate of 26 acres and four square miles; if the competent electrician used an uninsulated conductor, the potential of that conductor would not be substantially zero. It would probably be two or three volts away from zero, and that would eat it through in a very

CASE I.—NO EARTH RETURNS. NO BATTERIES.

Light Load.



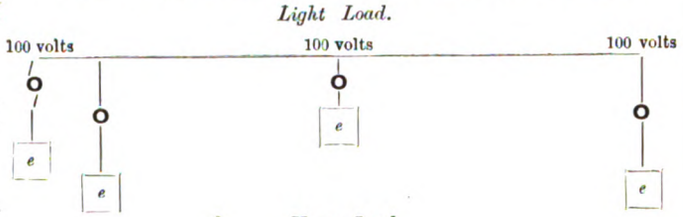
Heavy Load, large fall due to the draft from the mains.



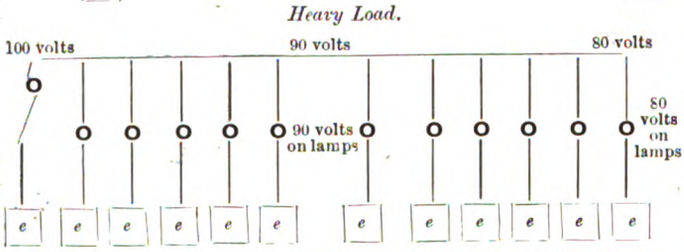
Result variation of pressure on distant lamps—100 to 60 volts.

CASE II.—EARTH RETURNS OF NO RESISTANCE. NO BATTERIES.

Light Load.



Heavy Load.

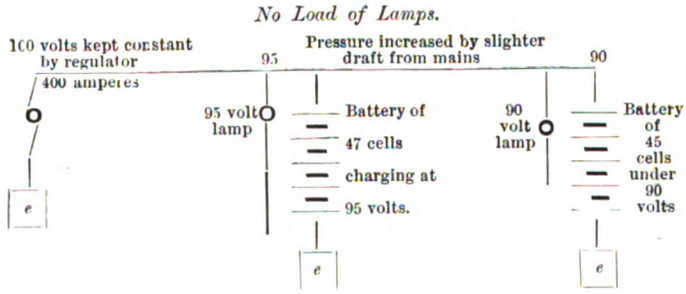


Result variation of pressure on distant lamps halved—100 to 80 volts.

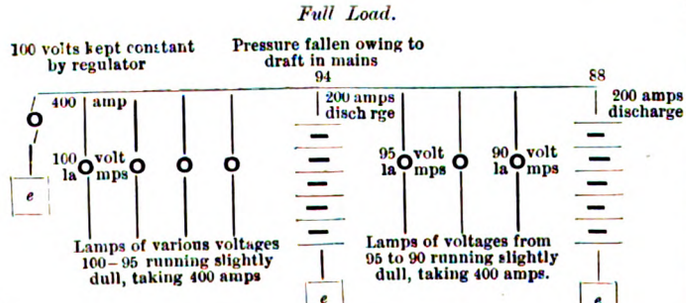
Half the cost of conductors saved.

CASE III.—EARTH RETURNS AND HYPOTHETICAL BATTERIES.

No Load of Lamps.



Full Load.


100 volts kept constant by regulator
Pressure fallen owing to draft in mains
94
88
400 amp
200 amps discharge
200 amps discharge
100 volt lamps
95 volt lamps
90 volt lamps
Lamps of various voltages 100–95 running slightly dull, taking 400 amps
Lamps of voltages from 95 to 90 running slightly dull, taking 400 amps.
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short time. He (witness) assumed that Mr. Lane Fox thought he would save half the drop in the potential by the use of the earth, from his laying such stress in his Claims 1 and 2 upon the returns by earth. Witness having been asked about the preventing of flickering.

Mr. JUSTICE SMITH: Sir Frederick Bramwell always adhered to this, that the automatic part of it would not work. All the witnesses for the defendants adhere to that.

Mr. MOULTON: No, my lord, with regard to stopping the flickering.

Mr. JUSTICE SMITH: They have undoubtedly admitted that there is a regulating power to some extent, if not to a considerable extent, inherent in a secondary battery applied to the main. I think they have admitted that, but they did stand hard and fast to this, that it would not work automatically.

The cross-examination being continued, WITNESS admitted that when one was on the plateau one got a large current through for a very small increase of pressure. Planté's batteries, as made by the original inventor, ran down very quickly by local action, and the coatings peeled off. They kept some charge in for a long time if one kept them fully charged, but if one charged and discharged them constantly they would not. He would not say a Crompton-Howell cell was a Planté. The last portion of the charge was, as far as energy went, largely wasted. It was for the purpose of preventing chemical action in the batteries. It was not necessary to go higher for the electromotive force, but it was necessary to bubble more in the present type of cell than in the Planté in order to be sure of complete conversion of the lead.

TUESDAY, MARCH 15TH.

Mr. JAMES SWINBURNE, recalled and cross-examined by Mr. MOULTON, said that when the battery was on the plateau a change of 1 per cent. would make a considerable current come out of the battery for a short time, and a rise would cause a considerable current to go in also for a very short time.

Re-examined by Mr. FINLAY, WITNESS said the current would last for a few seconds. After a few seconds the current fell to almost nothing. It would not last long enough to be of any effect in regulating in the sense used by Mr. Lane Fox. If Mr. Lane Fox had thought of feeders he would not have filed his application at all.

Mr. H. T. SHILLITOE, examined by Mr. R. W. WALLACE, said he was electrician to the Marquis of Salisbury, and had had charge of the installation at Hatfield House from the first. That was from about the year 1879. The electric current was conveyed to the house by leads hanging on poles insulated by ordinary porcelain insulators. The return was attached to the water-pipe that ran from the saw-mill to the house. The wire was carried from the negative side of the dynamo, twisted round the water-pipe and soldered to it. For some time it worked very well, but it was more or less the whole time in use very erratic, frequently being eaten off near the pipe, and the connection broken entirely. As a remedy they used an insulated return. When they first began they ran something like 20 amperes.

Cross-examined by Mr. MOULTON, WITNESS said that they used an alternating current of high tension, 500 or 600 volts. The shocks from alternating currents were undoubtedly far more severe than from direct currents. He would not like to touch any portion of a system with 800 volts alternating unless it was well insulated. If they had a system insulated all over with 800 volts alternating, and any person touched a bare portion of a conductor, he would receive a still more strong shock.

Mr. DORNER, examined by Mr. FINLAY, said he was an electrical engineer, engaged by Messrs. Siemens Brothers. Since 1866 he had had experience of electric lighting practically. Since 1877 his first experience was putting up the electric light at the Lizard Lighthouse. He was engaged in putting up an installation at Lord Armstrong's house at Craigside in 1878. The dynamo was between a mile and a mile and a half from the house, driven by water. They used about 15 amperes. The voltage was 50. The outgoing conductor was insulated, a bare copper wire on posts. He found in the house a water-pipe going down to a lake, and this he used instead of an earth-plate. He connected by an insulated wire, and soldered it down to the pipe. It did not work. The dynamo did not excite itself. He could get no current from it because the circuit was not complete, and the resistance between the two pipes was so great they would not pass the current through the complete circuit. After that he put another metallic return wire up in the same manner as he put the main wire, and then it worked all right. As an electrical engineer of experience, if he had been working under the specification he would have put two earth-plates in.

Cross-examined by Mr. MOULTON, WITNESS stated that if the two earth plates had not worked he would have put a metallic return.

Prof. A. B. W. KENNEDY, examined by Mr. R. W. WALLACE, said that in the ordinary course of business of the Westminster Electric Light Corporation he had made certain tests of the working of the batteries. The tests were in no way in contemplation of this action. They were the ordinary tests before accepting the batteries on the part of the Company. They were all made in the course of last year. The conditions which had to be fulfilled by that test were that the battery should be previously fully charged, and should then discharge 400 amperes at 90 amperes per hour, and then should fully discharge itself. The conclusions he drew from the whole curve handed in were first that the charging had to go on on a very much higher level than the discharging necessarily; second, that the pressure fell very notably indeed (6 per cent.) during the course of the discharge; the third, that the discharge line was extremely uneven because of certain irregularities in the resistance that the battery was discharging through; the point of interest was that the pressure in the battery followed all the larger irregularities very minutely. Witness then gave some details as to his experience of lamps being switched on and off. A church was suddenly switched off, and the neighbours were very much disturbed and came to worry him. He had the batteries on. The switches were on, but the drop occurred before they knew anything about it—before they could touch the switches—which caused the people to complain that their lights flickered very badly, and he had no doubt they complained quite rightly. He only wished that if an arc lamp was turned off, or on, on his circuit the batteries would prevent any flicker. He had two or three consumers who used large arc lamps for photographic purposes, and the best of his endeavours had not been sufficient to induce them to put them on and off, so as to prevent annoyance to their neighbours. They were large 40 ampere lamps. The batteries did not act as regulators under those circumstances. The batteries were always on.

Mr. JUSTICE SMITH: This gentleman tells me they are always on, and according to this gentleman they regulate a certain amount, but not above a certain amount; that is his evidence. Other gentlemen say they regulate more than this gentleman says they do. First there will be a question what amount of regulation these batteries are able to exercise at all—whether it is appreciable, or of value. I have been sitting day after day hearing this, and we must keep to the points. I have to decide at last, and not wander all over the place. When you switch in a battery on your main do you not do that for the purpose of keeping it constant?—My load increases, and I have to increase the pressure at my station in order to drive current through the mains. If I left the switch where it is I should unduly drive too much current through my batteries, because there is only a certain number of cells, and the increase of pressure depends on the dynamo. If I increase the pressure by opening the throttle valve and letting the engine run away, I might harm the battery by putting through too much, and I switch up one cell to increase the pressure at the station without harming the battery. I can put any amount of pressure through the cells if I drive it hard enough.

Continuing, WITNESS said the use of the battery was to give a current at the time the dynamo was not working. A battery without switches would not have any effect as a regulator The battery would soon be destroyed, and the effect on the lamps, supposing lamps were interposed between the dynamo and the battery when charging or attempting to charge, would be similar. If the batteries had been filled and the dynamo stopped working, and the current was required on the mains from the batteries, the result would be on the lamps. Supposing the battery was only at 100 volts or 102 volts, that would not give sufficient light.

After cross-examination of the WITNESS by Mr. MOULTON and re-examination by Mr. FINLAY,

Mr. BERNARD DRAKE was examined by Mr. FINLAY, and stated that he first began to pay attention to the subject of secondary batteries in 1883. The Paper he read before the British Association in 1886 showed clearly the result of the experiments he had made at the Power Storage Company, namely, that accumulators made of lead must be charged to 2·5 volts per cell to enable the plates to last at all and work. They always charged fully in every house they had lit.

Mr. JUSTICE SMITH: How long has that been going on?—Since 1884, my lord, when I made the discovery that it was necessary. That was the essence of my Paper to the British Association.

Mr. FINLAY: What is the object of the secondary batteries?—As a reservoir, to enable the engineer to stop his engine at night.

Mr. JUSTICE SMITH: Supposing, Mr. Finlay, it be the fact that there is an inherent property of regulation in the battery, and you take the whole thing and use it for another purpose, you cannot help having the regulating effect. Is not that an infringement?

Mr. FINLAY: I submit not, my lord. I shall deal with that. It really, if you think of it, comes to this: the plaintiff is claiming for one quality in a thing that existed before his time.

Mr. JUSTICE SMITH: No; he claims for something which he says he has found out, and which has this inherent quality. Now, can a person take that thing and use it for something else without infringing?

WITNESS was then cross-examined by Mr. MOULTON, and re-examined by Mr. FINLAY.

Mr. FRANK KING was then examined by Mr. R. W. WALLACE, and his evidence consisted almost entirely in description of experiments specially carried out for the purpose of this trial.

WEDNESDAY, MARCH 16TH.

Mr. FRANK KING was recalled, and his cross-examination by the ATTORNEY-GENERAL continued. At the conclusion of the cross-examination Sir HORACE DAVEY pointed out that Prof. Thompson used an edition of 1884 of Sprague, and that the edition in existence in 1878 was the edition of 1875, which did not contain the definition or dictum which was quoted. In the one used it was "'earth,' a name derived from the old mistaken notion that electricity is pumped up from the earth as a great reservoir. Putting to earth and earth connection means a general return circuit which, for economy, is formed through the earth by means of earth-plates buried in moist strata at the various necessary points, but any conductor common to several circuits is technically called earth." That was in the edition of 1884, but the edition of 1875 did not contain the definition of "earth."

Mr. FINLAY then proceeded to sum up the evidence on behalf of the defendant Company. His observations would naturally group themselves round three heads. The first was, the process described in the specification was, they alleged, an unworkable one; secondly, there was no patent for regulation, and, if there were, it would be bad and not the subject-matter of a patent; and the third was that there was no infringement. One would have expected, if the patent really contained within it the valuable invention his learned friends relied upon, it would have been heard of a very great deal sooner. It had only emerged and come before the Courts in the year 1892. No adequate explanation had been given for that delay, and the true reason was that the patent was not worth anything. He submitted that the meaning of the term "the earth," as employed in the specification, was simply a question of the plain ordinary meaning of the

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English language. All the electricians in the world might come and give evidence as to technical meanings and so forth; but he submitted that nothing would serve his learned friends' purpose beyond demonstration, that to an electrician in the year 1878 a direction to use the soil of the earth would mean a direction to use something else. Unless his learned friends could establish that they had nothing. That, of course, was perfectly impossible. It would be contradicting the plain meaning of the words of a document which the Court had to construe.

Mr. JUSTICE SMITH: I agree with you. I have said so dozens of times in these fourteen days, but it has gone on. However, never mind, we are getting on now.

Mr. FINLAY: I submit, after all the flood of learning we have had on this point, it comes back to the meaning of the English language, and I defy my learned friends to make out that it means anything but what it says.

Mr. JUSTICE SMITH: Suppose you get as far as this. I am to read it as soil of the earth; how do you say I am to show it is unworkable? What do you measure unworkable by? At one gentleman's house it was got back with 15 amperes. That is sufficient for them.

Continuing, Mr. FINLAY said that the evidence as to Holyhead was a statement in answer to a question from his lordship as to what the witness had heard. The witness had never seen it, and knew nothing beyond what he said there. He (Mr. Finlay) did not think any cross-examination was directed to that point. The letterpress of the specification showed at page 4, line 55: "The cells should have a very large conducting surface, and there should be several batteries connected up at various points of the mains, so that by increasing the E.M.F."—and so on. It showed the patentee was describing a large system, and figure 3, which showed 328 lamps, was only a small portion, just enough to illustrate the sort of thing the patentee was at work upon. He submitted that the patent was directed to a large system of electric lighting for a district, with batteries scattered about at different points of the district, and with a very large number of lamps, 328 being shown in the small sample which was given in figure 3. Now, if that were so, the Holyhead instance, assuming it to have been proved, would really have no application. It was one case of arc lighting with a certain number of amperes. The evidence had clearly established that the earth would not work with a system of incandescent lighting, on account of the enormous size of earth-plates required. It was very instructive to recollect how this was dealt with by Prof. Perry. Prof. Perry read the patent as applying to the earth, and said there was no difficulty about the earth plates, and indicated the panelling of the court as about half the size of the limit. When Mr. Lane Fox came into the box, having had the opportunity of reflection, he had to say he entirely disagreed with Prof. Perry. He submitted after that it was impossible for his learned friend to sustain his contention, and that alone really made an end of the case. The defendant Company's witnesses had proved that not one instance of the application of earth returns to incandescent lighting could be produced. That spoke volumes, and ought to be absolutely conclusive on the point. He would now pass on to the next point, on which he submitted that the patent was proved to be unworkable. His side said that one cannot work it without the arrangement of switches and extra cells, because if one did the lamps would be destroyed. His learned friends stopped at the plateau in charging, they only got their cells half full. They could not get the benefit of the plateau in returning unless they charged their cells full, because the plateau from "A" to "B" in returning was the level at which the discharge kept when the cells had not been filled full. How did his learned friends try to meet the necessity of switches and extra cells? Here, again, his opponents had two cases mutually destructive. At one part of the case, his learned friends' view was that the switches were unnecessary, and that people did not require all this switching in and out and extra cells if only large plates were used, and, as they put it, kept upon the plateau. Then further on in the case, when the other side was pressed, with his evidence, questions were put indicating their view was that any competent workman would have known about switches. Switches, his friends said, were not a novelty, and any competent workman would have seen they were necessary. His learned friends had liberty to put forward those two cases; but then he was at liberty to point out that they are mutually antagonistic and destructive. About the fifth day of the case a number of questions were put to Sir Frederick Bramwell, and probably to other witnesses, indicating that his learned friends' case was that they were for the relapse, so to say, in secondary batteries, owing to its having been forgotten that Planté's form was really the best form of all. Now he claimed to have destroyed that idea altogether by his evidence. He submitted, conclusively to the Court, that the failure that took place was due to the non-realisation that it was necessary to charge the cells fully, and not to the use of pasted cells. His learned friends said, "You do not want this arrangement of switches at all; make your cells large enough; make the area of plates in your secondary batteries large enough; have either your plates of very large size, or a great many plates of small size, so that you have a very large area of plates in the cell." In the first place, there was no direction for that in the specification at all. It had been clearly pointed out that the internal resistance of the cell was an insignificant fraction as compared with the back E.M.F., caused by the chemical action which took place. That one did not get rid of by large cells at all. The speculation, for it was really nothing else, had never been carried into practice; nobody pretends to have solved the difficulty by having batteries of the size shadowed forth, or anything approaching it—it was a mere speculation—and he submitted that that speculation had been absolutely destroyed by the practical evidence given on this part of the case. Where, again, did they find the direction to keep on the plateau?

Mr. JUSTICE SMITH: What they say against you there is that Planté says you are to go to bubbling; the bubbling goes up to "B," and therefore you are not to go above "B." That is their case put shortly.

Mr. FINLAY, continuing, submitted that the other side did not in any way incorporate the direction into the specification. With regard to his contention that the thing was unworkable for want of switches and extra cells, and the answers of his learned friend that these were not really wanted, he would point out that in practice, with two exceptions, which really, when they were examined, came to nothing, in every case which was claimed as being an illustration of the use of the patent, switches and extra cells had been used. He would not deal with the expense of the enlargement of the plates. He had pointed out, as a matter of fact, that the increase in the size would not effect the object desired. As to using the cells in the way the other side said they should be used, would destroy the cells. On that point he had a very strong case. His side had given, not merely experiments, but the results of experience of actual working. Experiments were most valuable if you could be satisfied about all the conditions; but the result of experience in actual working was far more valuable than experiments, because that experience was not acquired with a view to the particular case. His side had given this body of practical men to show that to work the cells in the way the plaintiff said they should be worked to carry out the specification, would destroy the plates and cause the buckling to which reference had been made so often in the case. His learned friend's alternative case was this:—"Assuming that the Court thinks that all our evidence that it could be done by the use of the plateau and the large cells and watching the lamps to see whether things seemed to be getting critical with it owing to the rise in voltage—assuming that is to be thrown overboard, we have an alternative case, and say any competent workman in 1878 would have known that and put in switches, and that is a merely mechanical arrangement which would be supplied by the mechanical workman who read this specification in the year 1878." That was making a very large draft upon the ability of the workman. How could his learned friend, having regard to the language of the specification, and having regard to the passage in the patent of the same year, three days afterwards, 4,043, assert that a hypothetical workman would think of switches? The paragraph which was incorporated in the final of 3,988, was followed in 4,043 by a paragraph for the use of commutators, which was not incorporated. "Or I sometimes supply each of these reservoir batteries with commutators, and with the means of working them so that it will not be necessary to increase the E.M.F." The inference was irresistible that, in the paragraph that preceded, the action was to be automatic. He submitted that this specification did not show a patent for regulating at all. It was a patent merely for the use of secondary batteries as reservoirs of the electrical energy in combination with the system of distribution described. There was not in the specification a single word about regulating except by the regulator, which had since been disclaimed. On this point his friends were in a dilemma. If regulation was to be found in the final, it was a departure from the provisional, not in a matter of detail, but on the one point which was now claimed as the point of the patent. If, on the other hand, the final was in conformity with the provisional, then regulation was not there.

Mr. JUSTICE SMITH: Supposing the provisional said: "I claim for the secondary batteries that they keep up constancy," and then that the final had said: "I claim for the secondary batteries that they keep up constancy." Why am I to read that as not to mean regulation? Keeping constant means regulating. Leaving out the other regulator altogether for the moment, and supposing it stood like that alone, why ought I not to read it so when there is some evidence—when I say "some evidence" I mean a considerable body of evidence—that it had a regulating power? Why am I to read it that it does not mean to regulate? You have got a better point now, which I have never seen until this moment, namely, that they never claimed the secondary battery as being regulators at all in the provisional.

Mr. FINLAY: Yes.

Mr. JUSTICE SMITH: I see the point.

Continuing, Mr. FINLAY said the secondary batteries were introduced, and the description of the regulator was given in detail. That was the regulation which was said to be necessary—by the regulator. Then, when they came to the final disclaimer, he submitted that the attempt was being made to employ the word "regulating," which was contained at the commencement of the specification as disclaimed, in a perfectly different sense from that in which it was used at the commencement of the original.

Mr. JUSTICE SMITH: I agree with you there. I am reading now at line 44, on page 5, "And I declare that I claim as my improvements"—it originally ran thus—"in obtaining light by electricity, and in conveying, distributing, measuring, and regulating"—that "regulating," as it originally stood, I have no moral doubt referred to the electrometer. I have not the slightest doubt about that. It is a matter of construction.

Mr. FINLAY: I submit so, my lord.

Mr, JUSTICE SMITH: But then the difficulty I have, if I may say so, is this. Let me put my point to you. A man claims "A," and he claims "B." He claims "B" for regulating as well as "A," but he does not think that it will avail him so much as "A," but it turns out afterwards that "B" will regulate. Why cannot he disclaim "A"?

Mr. FINLAY: But he has not claimed "B."

Mr. JUSTICE SMITH: That begs the whole point as to what is the meaning of "constant."

Mr. FINLAY: Yes, but at the same time your lordship will see this. "Constant" of course, is a word which does not necessarily at all relate to counteracting momentary flickers. The meaning of keeping the force in the mains constant may be that you want to have the same amount of force available for all times, so that you can keep up your voltage to the required point, however great the load which the voltage has to carry may be.

Mr. JUSTICE SMITH: The evidence of a very eminent man is: "I think that secondary batteries would tend largely to correct the rise and fall of voltage when lamps were turned on and off."

Mr. FINLAY: I accept that fully.

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Mr. JUSTICE SMITH: How can you say afterwards that it is not so? I mean, all the gentlemen minimise it as much as they can, but they all have to come up to the scratch at last when they are cross-examined as to this.

Mr. FINLAY: Yes, my lord, I am ready to deal with it on the footing of what Sir Frederick Bramwell said, but what I point out to your lordship is this. What he says is: "They would have that tendency, but as a matter of fact we do not use them for that purpose."

Mr. JUSTICE SMITH: That is the other point on the infringement question, and I agree that you have a large body of evidence to show this. You have this proved, that these secondary batteries are not universally used. In a large number of installations they are not used, and in others they are, and I think, if I may say so, the preponderance of evidence is that they are not used for regulating purposes at all, but they are used for storage purposes, *de facto*, by people of competence. Does not the evidence come to this, that the plaintiff has put his case too high when he says that it will have such a controlling effect as the specification would lead me to believe, but it still has a controlling effect?

Mr. FINLAY: I submit it comes to more than that, namely, that they have put their case so high because it is only by putting their case so high that they could hope to make it applicable to us, because we do not use gas engines.

Mr. JUSTICE SMITH: You are now arguing the point that even if this claims a regulating process it does not regulate at all.

Mr. FINLAY: Yes.

Mr. JUSTICE SMITH: I am against you there.

Mr. FINLAY: Oh, I do not say that it does not regulate at all. I did not intend to put it so high as that.

Copious extracts were then read from evidence, and cases were cited in support of the contention that secondary batteries having inherently a moderate regulating effect, their power of regulation could not be claimed in a patent. It was perhaps a great "discovery," but not an "invention."

FRIDAY, MARCH 18TH.

The ATTORNEY-GENERAL, in closing the case, said that counsel who came into these cases cram up the alphabet before the case begins. The learned Judge was not in that position; and he hoped it would some day be more the practice to have assessors sitting with the Judge, because he was sure that time would be saved by not having to go through what he might call the alphabet of any particular science. The case was boiled down by his learned friend Mr. Finlay's most able speech to three points. One, that there is disconformity between the provisional and complete specifications; next, the patent is unworkable, meaning thereby that the specification is not sufficient; and third, that there is no infringement. As to any one of these points, he admitted if they could be made out in substance and not mere form, they were objections which would be fatal to this action. Sir Horace Davey said the main ground of infringement was that these batteries acting as regulators was not in the claim. He meant that there was disconformity between the provisional and complete, which was not exactly the same proposition of law, but it did to a certain extent cover the same ground. There were one or two general propositions. The first is that it is established in law that the thing does not cease to be an infringement because it is an improvement; secondly, that a patentee is not bound to write out, and ought not to write out, that which will occur to persons ordinarily skilled in the particular science to which the patent is addressed. The question is not what the infringer meant to do, not the object with which he has taken the so-called invention, but whether he has taken it. There is no authority or vestige of authority which suggests that if in the provisional specification you have described in general terms what you propose to do, that there is any disconformity because you do not point out the advantages either in the provisional or in the complete specification. The function of the provisional specification is to point out what the invention is, to identify the ambit of the invention. When the nature of an invention has been described in the provisional specification in the way which has been mentioned, if something were found out during the six months to make the invention work better, or with respect to the mode in which the operation may be performed—a thing which is very likely to happen when in carrying out his invention the inventor finds that some particular bit will not work so smoothly as he expected, and it is necessary to add a little supplement to it—still the nature of his invention remains the same, and it is no objection that in the complete specification which comes afterwards, the invention or application is described more particularly and in more detail, or even if it be shown that there has been more discovery made, and so as to make the invention which he has described in the provisional specification really workable. His learned friends had endeavoured in their argument and by their questions to cut down Mr. Lane Fox's regulation to nothing but the flicker when the gas-engine was running. From the point of view of utility it would be sufficient to admit that, but when he came to the question of infringement and of user, that the great discovery of Mr. Lane Fox was this: that you can have a constant pressure while you are discharging the batteries, of course the generator running all the time, and that the importance of the invention is that although you are generating more current than you want at the time the lamps are on, you store it up in your batteries to be ready to be used at the same pressure when you have more lamps—that is to say, less current than you want, or when the current is coming partly from the generators and partly from the batteries. That is what regulation means in this patent.

Mr. JUSTICE SMITH: What they say is, you claimed in the provisional for battery as a reservoir? And you claim in the complete battery as a regulator; that is what they say. You say it makes no difference.

The ATTORNEY-GENERAL: And more than that, my lord, I say I did not put in the provisional specification batteries as a reservoir only. In line 45, the E.M.F. in the mains is to be kept constant; and at line 36, a number of Planté's batteries will serve as a conductor of electricity. If the collocation and position of those things involves this necessary incident that out from the reservoirs come amperes when required, and into the reservoirs come amperes when required, that is what is pointed out in the provisional specification. He then passed to the question of sufficiency. It involved two important questions—that it is bad, because soil-returns are to be considered as the soil mode of return; secondly, it is bad because you do not find any mention of switches in the specification. With reference to devices to secure constancy of the electric light, it is admitted that Mr. Lane Fox enunciates that proposition for the first time. That is not enough. He must tell the public how to do it; and the question is, upon this matter, what was the method he devised for telling the public how to do it? You may require to run your generator at a time when your lamps that are on will require more current than your generator will ordinarily give out, and, accordingly, you must have the means,—and, he used this word advisedly, automatically. He would point out presently the defendants use it automatically unquestionably, whether they supplement it or improve it for certain purposes by the manual action of switching in boxes, but they use it for periods of hours, on the evidence of Mr. Miller, automatically. He cared not whether it be more corrected when they used switches than without switches; the point he took upon this is that the constancy in the mains depends upon the combination of a current from the generator and a current from the batteries, the batteries being so coupled up (that is the feature) between the return wire and the main, the main and the earth, that it must have the function which they were considering when enunciating a principle of which electricians had never even dreamed, and it was no exaggeration. He cross-examined one of their witnesses—Dr. Hopkinson—as to the number of distinguished men who gave evidence before the Electric Light Commission in 1889, while Mr. Lane Fox's document was a secret paper—a concealed paper—and there were men like Sir William Thomson (the present Lord Kelvin), Sir William Siemens, Dr. Hopkinson, and many other distinguished gentlemen, not one of them regarded the sub-division of the electric light so that a constant current could be maintained as within the range of practical electricity. Then to say it is to be treated either as a matter of common knowledge that you could put together as Planté batteries or electric generators, or that the function which they are to perform, in itself new—in itself absolutely new—the function that these secondary batteries are to control the E.M.F. in two ways—they, in the first place, take up excess voltage; and, in the second place, take up excess amperage, that they in the first place give off additional voltage if required; and, in the second place, they give off additional amperage—that is enunciated on both points of view by Mr. Lane Fox in plain and simple language. He submitted that that is not to be treated as not enunciating an invention of the greatest novelty, however much it may be improved now, is not doing justice to Mr. Lane Fox, and is to construe this specification according to the criticism of people who have absolutely done nothing to improve Mr. Lane Fox's system except add a discharging switch.

On passing to the construction of the specification in regard to earth, Mr. JUSTICE SMITH said: The first question is, What does "the earth" mean in this context?

The ATTORNEY-GENERAL: Certainly, the first question is, "What does the earth mean in this context?" "The earth" means in this context, and ought to be taken to mean by everybody who read this specification in the light of the then knowledge, any return which is available for distributing light. He submitted that it does mean in fact, and would be taken to mean for the purpose of patent law, any return which fulfils the condition of the return contemplated by Mr. Lane Fox.

Mr. JUSTICE SMITH: What do you say to this proposition: supposing Mr. Lane Fox's idea was to have an incandescent lamp, and he certainly had the idea of having 400 or 500 lamps at the least; and suppose it turns out that the earth-return for 400 or 500 lamps was imperfect, what then?

The ATTORNEY-GENERAL: If so, this patent is perfectly good, my lord; and I will tell your lordship why, because the question you have to consider is whether or not the particular method of return he contemplated is "of the pith and marrow of the invention."

Mr. JUSTICE SMITH: That is another point. Let me see if we agree in the law. Suppose it is the pith and marrow that it should be the soil?

The ATTORNEY-GENERAL: Then, my lord, I should be wrong, wrong completely; if it is "the pith and marrow," I am done altogether.

Mr. JUSTICE SMITH: You would not say if it would return 10 lamps and he claims 400, that it would do?

The ATTORNEY-GENERAL: No witness has suggested that the increase of the number of lamps would create the slightest difficulty in carrying out Mr. Lane Fox's invention, unless they construe it that it must be soil and nothing else. My learned friend will see that I am right upon this.

Mr. JUSTICE SMITH: I agree with you, if you are entitled to use any return other than soil, you can get it back easily.

The case of Brett was then cited by the ATTORNEY-GENERAL. This was a patent by Cooke and Wheatstone, for electrical alarums worked by currents transmitted through metallic circuits. After the date of the patent (1837) the use of earth as a return was discovered. The infringer used earth. It was insisted that no infringement had been made by the defendants, or, indeed, could be made, as long as the circuit they used was not metallic throughout, but to a substantial extent non-metallic. "The circuit used by the defendant was metallic in all that part which operates in giving signals, and in all the parts to which the plaintiff's alleged improvements applied, and it was no condition necessary to the existence of the improvements that the circuit should be metallic in any other part than that which contains the coils and operates on the needles." When the electricians come and stand in this Court and bring the power of their combined in-

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telligence to endeavour to show that Mr. Lane Fox's patent is bad—they have been brought up to the mark to do that, and give their view, of course, with perfect candour, though sometimes their view is a little warped—there is not one mind which ventures to say from practical electrical working the system of distribution is altered one whit by leaving out soil, and putting in either insulated or uninsulated return. Of course the nearest parallel would be an uninsulated return of copper wire. These complications of charging which they have introduced, in order to try and get out of the most obvious infringement—charging high—is simply and solely due to the fact that they, for the purpose of economy, choose to have a larger number of cells than they need, and therefore they must have a shifting charging switch as well as a shifting discharging switch. If they had not more than 50 cells they would never want anything but a discharging switch. These complications Mr. Crompton has introduced, on which they say the system can only be worked, namely, by having a charging as well as a discharging switch; but it is simply and solely due to the fact that they wished to charge, for the purpose of economy, a larger number of cells than they need. The contention is twofold—that you cannot carry out Lane Fox without a discharging switch, and that you cannot carry out Lane Fox as the defendants do without a charging switch. On the question of sufficiency of specification, he submitted that the discharging switch was the only important one. On this question of sufficiency he was taking Lane Fox pure and simple. [*The model* was put before his lordship.*] The position, "D," Dr. Hopkinson admitted is Lane Fox pure and simple during the process of charging. "E" is Lane Fox pure and simple during the process of discharging. He was not dealing with the question of the balance in between. That comes at a later point. Now, he would assume for the moment that the man was going to work out Lane Fox pure and simple; that he has got no movable charging switch, and he would take any number of cells—it does not matter whether they took 51, 52, or 53. He asked his lordship kindly to put the discharging switch at 50, and his lordship might put the charging switch "X" at the same point, or higher. That is the position of things in which Dr. Hopkinson admits that as long as it is used in that position it is Lane Fox pure and simple. Now what happens? What is the problem that an ordinary electrician has got to solve? Of course, there must be a switch to get into the main.

Mr. JUSTICE SMITH: How do you mean there must be a switch to get into the main?

The ATTORNEY-GENERAL: The boxes must be connected with the mains by means of a switch. The direction of the specification is that they are to be coupled up between the mains and the earth. When he used the word "switch" he merely meant a connection. He was assuming that the gentleman starts having nothing but the Lane Fox specification before him, with the switch at 50. [He then read the description† provided with the model, and a passage from the specification.] Dr. Hopkinson admitted that as long as they had got the two switches opposite one another, they had got the absolute letter of the thing that Mr. Lane Fox describes. Why was the discharging switch "Y" to be shifted down? It was because the E.M.F. in the secondary batteries was rising. He would for a moment consider the three directions Mr. Lane Fox had given, and the common electrical knowledge at that time. First, they had to charge the batteries, and accordingly connected the top battery with the main, and proceeded to charge, raising the E.M.F., as Mr. Lane Fox directed them to do, in the mains. The other direction he gave was that the pressure in the lamp main was to be constant. He asserted as part of his argument, and his strongest argument in this case, that the only thing that was necessary to work Lane Fox according to the best possible way was to put in a movable discharging switch, in order to do the very thing which he told them to do—to keep the E.M.F. in the mains constant, and to vary the number of cells according to the E.M.F. in the mains. Prof. Forbes said it was everyday work in all electrical work to attach the wire to different points of a battery, so as to use more or less cells. It was done every day in telegraphy. The other condition of things which was said to be new is, that if you desire to charge very highly you must have a switch to enable you to move the switch back for the purpose of high charging. It had nothing in the world to do with Lane Fox. It had not the slightest relation to Lane Fox. It was never known at that time, and it is the subject of a subsequent invention, and had nothing in the world to do with the regulating, with the storage, with the kind of reservoir, or anything of the kind. The whole of this question of charging batteries to excess had been introduced into this case for the purpose of suggesting, that at the outside, what was an improvement of Mr. Lane Fox's was that which can be used to show that Lane Fox had made no invention. The whole point of this was that in 1884 it was discoved by Mr. Drake or Mr. King that it was desirable, from the point of view of health, to keep batteries healthy by charging very highly, as distinguished from charging as people believed before. Nobody suggested that they act differently when they are in a condition of health. They provided that, instead of charging only 50 cells, they should be able to charge whatever the proper number may be by moving the switch back, and it has not the slightest relation to the question of how Lane Fox acts either as a reservoir or a kind of reservoir or a regulator. Mr. Drake made the discovery of charging these cells, and he does not suggest that there was any difficulty in applying it. The point is this—that at the time of Lane Fox they thought that it was prudent to charge low, and in the time of Drake and Gorham they thought it prudent to charge high, and that extra charging switch is simply inserted in that Kensington installation because they wanted to be able to have a larger number of cells, and so reduce the voltage, instead of having a larger number of batteries standing side by side. Did his learned friend suggest that an improved method of charging, whereby they keep the cells healthy in other conditions using Lane Fox, would not be an infringement? He said there is not a vestige of an authority for that contention in the books.

Mr. JUSTICE SMITH: Taking what you are saying about keeping it healthy, they say you must charge up to 125; but they say the result will be to blow your lamps out, and it is no good doing it at that; and they say that you cannot do without some switching arrangement.

The ATTORNEY-GENERAL: Will your lordship kindly take the model before you, and will your lordship suppose that a man working Lane Fox thought it prudent for the sake of health to work up to 125, what has he got to do? It makes no difference for this purpose whether it is 50 or 56 cells.

Mr. JUSTICE SMITH: I quite agree with what Lord Herschell said with reference to the law on this subject, and I must go back to 1878. I am going to make this distribution; but how many lamps am I to blow to pieces before I find it out?

The ATTORNEY-GENERAL: You will not blow one lamp to pieces, my lord.

Mr. JUSTICE SMITH: I do not want to trouble you about the infringement, because, if you are right on the other points, I can find infringement very easily.

The ATTORNEY-GENERAL: He takes 50 cells or any number you like—I may as well take 50. He charges those cells, and finds out, following Lane Fox's directions, that he ought to raise the E.M.F. to 125 in order to charge those properly. The voltage in the secondary battery is rising in consequence of the extra pressure in order to charge. What has the man who watches the batteries to do? He knows from his primary battery that if you have too many cells discharging you will get a higher voltage. He is told by Lane Fox that the number of cells in the batteries is to depend on the E.M.F., and he is told that the E.M.F. is to be kept as near constant as possible. Five witnesses of experience have told your lordship that it was common knowledge to add that discharging switch; and, my lord, I say there is no witness who suggests that it was not common knowledge. Why is this man to shut his eyes to everything that Planté had told him? Now, the competent electrician in the year 1878 knows this—that if he keeps the voltage going out into his lamps constant, of course he will not break his lamps down. The competent electrician knows that the effective voltage comes off on the discharge of either the primary battery or the secondary battery, and yet it being common knowledge, known every day, how to reduce the voltage coming out from an accumulation of cells, by cutting off some of the cells, you are to be told that the patent is to be bad because the patentee has not repeated that common knowledge. In conclusion, the Attorney-General said that in this case there was a a very large and powerful combination against Mr. Lane Fox. One Company, and not by any means an unimportant Company—namely, the Swan and Edison Company—paid him a royalty in respect of this very patent. He was not there to say one word in favour of Mr. Lane Fox apart from this invention. Attempts were made to say that he was a very young man, attempts were made to suggest that he was only a dreamer, and it was suggested that vague generalities were all that he indulged in. The strongest testimony to the merit of Mr. Lane Fox's case may be summed up in two sentences, that, whether there were installations without secondary batteries—which he had no doubt there were, perhaps by the hundred—or not, hundreds and thousands of installations in this country have been erected and set up, and are still working, in which the position of these secondary batteries and their relation to the generators is identically the same as in Mr. Lane Fox's specification, written in the year 1878.

[THE JUDGMENT WAS RESERVED.]

* *The Electrician*, March 18, p. 518.
† *The Electrician*, March 18, p. 519.

On Saturday last the case of RICE *v.* EWING, Managing Director of the Archer Pipe Company, came before Mr. Commissioner Kerr, in the City of London Court. This was an action in which the plaintiffs, Rice Brothers, of 1, St. Swithin's-lane, London, E.C., applied that the defendant, Mr. R. Ewing, of Avenue Mansions, Shaftesbury-avenue, W.C., should be committed to Holloway Gaol for the non-payment of £10. 18s. 1d. due. Mr. Commissioner Kerr having asked the position of the Company and the value of its shares, plaintiffs replied that the Company was a flourishing one, and that the defendant held 1,885 of the shares. Mr. Commissioner Kerr made an order for the defendant's committal for ten days.

Changes in the Conductivity of Water when in Contact with Glass.—It has been long known, says *Nature*, that glass is attacked and dissolved in small quantities by ordinary water. This dissolving process Herr Pfeiffer has recently sought to prove and measure by change in the electric conductivity of the water (*Ann. der Physik*). He measured the increase of conductivity undergone by 1 cubic centimetre of pure water when it has been in contact for one hour with one square centimetre of glass surface, and concluded that the amount of glass dissolved at 20°C. was 1 to 2 millionths of a milligram. He found, too, that with the temperature rising arithmetically, the growth of solubility is considerably more rapid than that of a geometrical series; that the increase of conductivity of the water for a given kind of glass under like conditions is a characteristic constant; and that later, when a certain quantity of alkali is dissolved, further action involves a dissolving also of silicic acid, and the salts then formed may cause a decrease of conducting power.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March* 11, 1892.

The Incandescent Lamp Trade.—The important suit of the Edison Company against the United States Electric Light Company, which was decided by Judge Wallace last year, and which was appealed against by the defendant, has not yet come for decision in the higher Court. It is not at all likely that the case will be reached before July, and perhaps not until next October. One of the Judges of the higher Court has declined to sit in this case, as he has interests that prevent his rendering an unprejudiced decision. It is therefore necessary for the United States Senate to confirm the appointment of a substitute; and owing to the serious illness of the Chairman of the Judiciary Committee of the Senate, no Judge has yet been recommended for the position. In the meantime, the 10 or 12 incandescent lamp companies are turning out as many lamps each day as ever, although it may be said that very few if any of them are making any efforts to increase their facilities for the manufacture of lamps pending the decision in the higher Court. A careful estimate of the daily lamp production of all the companies in this country, made by the president of one of these concerns, places it at 27,000 per day. About one-third of this production is credited to the Edison Company, about one-sixth to the Thomson-Houston; and it is thought that the average price received is very close to 40 cents per lamp. This is based upon the fact that the Edison lamps are sold to supply companies at 36 cents, and to Edison central stations for 32 cents, while the average price for which nearly all of the other companies sell their lamps is not far from 44 cents. The smaller companies say that they are able to compete with the Edison lamps very effectually, even when their prices are 10 cents per lamp higher than those of the Edison Company, since it is said that although the initial efficiency of the Edison lamp is high, its average efficiency is not nearly so high as that of the other companies. Those who are now manufacturing lamps under other than Edison patents do not feel very seriously disturbed, since it is thought that even should the higher Court render a decision against the rivals of the Edison Company that company would not care to summarily suppress the smaller concerns and assume the work of turning out the entire production of the market, as this would necessitate the establishment of a very large plant, which could, at best, be kept in service for only that length of time which the fundamental patent in question still has to run.

German Competition.—Considerable discussion has been started the past week by the report that the German manufacturing firm of Siemens and Halske was about to establish in Chicago, on a very large scale, a plant for the manufacture of electrical machinery and electrical appliances generally. The report is given out on good authority, and, indeed, a company has already been incorporated to undertake the business. It seems to be the general opinion that the new company will be a formidable competitor of the largest of the American manufacturing concerns. The rumour, which, however, does not seem to have gained much credence, is to the effect that Siemens and Halske intend to form a combination with the Westinghouse Company, and to enter into direct competition with the Thomson-Houston-Edison Consolidated Company. It is thought that there is a good field for a new company of this kind, but that it must manufacture American apparatus instead of attempting to introduce German apparatus into use.

The Telephone Monopoly.—The position of the American Bell Telephone Company and its ability to control the telephone business after the expiration of its fundamental patents was recently very thoroughly discussed by Herbert Laws Webb in one of the monthly magazines. Mr. Webb takes a very sensible view of the case, and maintains that while the fundamental patent was at one time the main resource of the company it has long since ceased to be such, and that the system which the company has built up and the hundreds of patents it now controls, as well as the immense amount of capital it has invested in overhead and underground lines, will be sufficient to make it next to impossible for any competing company, especially in large cities, to gain any considerable foothold. This is a view of the case which the general public does not appear to have fully considered; it has been carried away by the argument that since the fundamental patent was the one which gave the company its monopoly the expiration of that patent would throw the telephone business open to the public, and that then an efficient and satisfactory service would be obtained at a small fraction of the cost which every telephone user is compelled to pay at present.

CORRESPONDENCE.

OIL AS AN INSULATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The use of oil as an insulator has been recently brought before our notice by the charming experiments of Mr. N. Tesla, and the important Paper of Mr. Hughes (read before the Inst.E.E., March 10, 1892).

As I have had some experience of the behaviour of resin oil, may I be allowed to give a brief summary of some of the ways in which it has been used in our laboratory here? In Fig. 1 is shown a Leyden jar, arranged in a bath of oil. A A and B B are the inner and outer coatings of the jar. The outer vessel C C, and the jar are filled with oil up to E. The jar is supported on cotton wool, saturated with oil. D F are two rods of metal, held in position by a cross piece of ebonite; these can be lifted out of contact with the coatings of the jar by the ebonite handle G. To charge the jar D F is let down till it touches the coatings; after the jar is charged, it is lifted out of contact; when the jar is to be discharged the rods are again lowered to touch the coatings. In Fig. 2 is shown a ful-

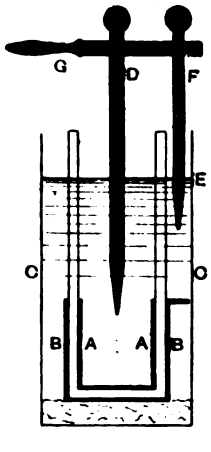

FIG. 1.

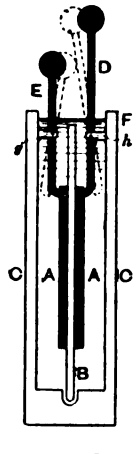

FIG. 2.

minating plane B, also placed in a bath of oil C C. It is filled up to F. A A are the opposed coatings of the plane. D E are two levers whereby the plane is charged and discharged; they move about points at g and h, so that after charging they can be put out of contact with the coatings of the plane. The levers are moved either by silk threads or by an ebonite rod. The resin oil used was supplied to me by Messrs. Elwell-Parker and Co., of accumulator fame; it has been in constant use for three years.

On the dampest days the jar or plane keep their charge well; after ten hours the spark is reduced to about half its original length. Long after the time I have mentioned, the plane will fire a blasting detonator. I have also used oil in a large battery of very small cells used to charge the needle of the quadrant electrometer of Lord Kelvin.—Yours, &c.,

FREDERICK J. SMITH.

Millard Laboratory, Oxford, March 17, 1892.

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SOME EXPERIMENTAL INVESTIGATIONS OF ALTERNATE CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the authorised abstract of the discussion published in your last week's issue, I am represented as having said precisely the opposite of what the transcript of the shorthand writer's notes correctly reports me to have said. I remarked that in two transformers, both giving 95 per cent. efficiency at full load, and having the iron to copper losses as 3 to 1 and 1 to 3 when so loaded, the 24-hour efficiency taken on a central-station midwinter curve, similar to that of the Kensington and Knightsbridge Company, comes out at 76·3 per cent. and 87·9 per cent. respectively; thus showing the effect produced by varying the iron and copper losses, even when the sum of the two at full load remains the same. I have not worked out the efficiencies for the summer load, and am therefore unable to give the mean for the year; but it will be readily seen that taken over twelve months, with the lowering of both efficiencies, there will be manifested a still greater advantage on the side of the transformer having the greater copper loss.

I take this opportunity of protesting against the present custom of publishing a scrappy report of the Institution proceedings as an "authorised" abstract. It has always been most unsatisfactory.—Yours, &c., W. B. ESSON.

March 22, 1892.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.

The tenth annual edition of the above well-known annual is now ready, price 7s. 6d.; post free, in the United Kingdom, 8s. 3d.; abroad (with the exception of a few countries), post free, 8s. 10d.

The edition consists of between 900 and 1,000 pages, and special care has been taken to make the Directorial division of the book, which has been considerably extended, thoroughly accurate and reliable. In this respect no possible comparison can be made with any similar publication.

To the Handbook division has been added several features which will be found of service to the Electrical and Allied Trades. The Digest of the Law of Electric Lighting has been thoroughly revised and brought up to date, and the most recent Board of Trade Regulations are also included. The various tables and tabulated statements have been remodelled and amplified; and a new feature is the tabulation of valuable information respecting Electrical Limited Liability Concerns.

An important feature is the space devoted to the officials of Foreign and Colonial Governments who have the superintendence of contracts and the giving of orders for electrical plant and apparatus; and as this has been kindly supplied by the various Government departments, it can be relied upon, as can also the particulars given respecting the Home Government departments.

The profession will find "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK a trustworthy work of reference, and purchasers of plant and apparatus may confidently turn to its pages for the names of all the principal firms supplying their requirements. Nearly every firm of any standing in the Electrical and Allied Trades is represented in its advertisement pages.

A digest of the contents of the book will be sent on application.

TENDERS INVITED.—The Urban Sanitary Authority of Basingstoke invite tenders for lighting the borough by electricity, gas, or otherwise for a term of five years. Tenders to be in by April 30th. Further particulars of the Borough Surveyor, Town Hall, Basingstoke.

——— EXTENSION OF TIME.—The Glasgow Corporation announce an extension of time for sending in tenders for engines and boilers, from the 29th inst. to the 5th prox., at 10 o'clock in the fore-noon.

——— The Lancashire and Yorkshire Railway Company are inviting tenders for stores, which include brass and copper tubing, signal and telegraph fittings, signal and telegraph wires, wire, wire rope, &c. The tenders have to be in by April 4th. Further particulars of Mr. C. W. Bayley, Hunt's Bank, Manchester.

TENDERS INVITED.—Contractors will remember that the tenders for the wiring and fittings for lighting the buildings known as the Railway Clearing House, are to be in by Wednesday, the 30th inst., and that the tenders for providing and erecting engines, dynamos &c., at the central station of the Glasgow Town Council must be sent in by the 29th inst. to Mr. J. D. Marwick, Town Clerk. The tenders advertised for by the Bristol Sanitary Authority for their central station at Temple Back are due this day (Friday).

TENDERS ACCEPTED.—The tender of Messrs. Fowler, Lancaster and Co., of Graham-street, Birmingham, has been accepted for the complete electrical installation at the baths and public offices of the Aston Manor Local Board. The amount of the contract is £1,594, the only other tender being that of Messrs. Verity and Son, of Birmingham, for £1,662. 7s. 6d. Mr. W. A. Davies, of Aston Manor, is the engineer for the work.

——— Mr. J. E. Johnson, of Highcross-street, Leicester, has secured the contract for the erection of refuse destructor buildings, with engine and dynamo house, boiler house, workshop, &c., which is to be erected for the Sanitary Committee of Leicester. The amount of the contract in all is £5,943. 4s.

ELECTRIC LIGHTING CONCESSION.—The town of Castro-Urdiales in Spain is about to grant an electric lighting concession. Offers will be received up to 26th May.

NYIREGYHÁZA.—The Municipality, after considering the advisability of erecting a central station, have decided to leave the financing of the undertaking in the hands of the contractors, and are accordingly prepared to grant a concession for lighting the town by electricity.

APPOINTMENTS VACANT.—The Electric Lighting Committee of the Town Council of the Borough of Nottingham require the services of a resident engineer, who must have had actual practical experience of installation working. Salary commencing at £300 a year. Applications must be sent in to Mr. Sam. Geo. Johnson, town clerk, The Guildhall, Nottingham. Further particulars are given in our advertisement columns.

——— A competent man is required to take charge of the central telegraph office at Accra, on the Gold Coast, where he will be required to act as Director of Telegraphs for six months, during the absence on leave of the permanent director. Terms are set out in our advertisement columns. Applications should be addressed to Mr. W. H. Preece, General Post Office.

MESSRS. C. E. G. GILBERT AND CO.—We are notified that this firm have purchased the business of Messrs. Adams, of Kensington High-street, which will be carried on by Messrs. Gilbert and Co. as their West End branch, the head office and works of the firm remaining as now.

THE MANCHESTER CENTRAL STATION LIGHTING.—The whole of the electric light cables for this large installation were supplied to Messrs. Mather and Platt (the contractors for the work) by the International Okonite Company. Only the best type of vulcanised india-rubber cables has been used; the specification requiring a very high insulation, both for the arc and incandescent systems.

MESSRS. DRAKE AND GORHAM.—This firm have been instructed by the Duke of Montrose to instal the electric light at Buchanan Castle. Messrs. Drake and Gorham will employ in this installation one of Gilkes' turbines, and the mains will be carried partly overhead, and partly on a modified trough system, based on the experiences obtained at Lord Armstrong's installation; the advantage claimed for this system is that it avoids the use of posts.

EXHIBITION AWARDS.—At the Exhibition recently held at Launceston, Tasmania, Messrs. Davey, Paxman and Co. have received the following awards for their engines and boilers:—A special first award for an 8 H.P. single cylinder portable engine, fitted with Paxman's patent automatic expansion gear; a special first award for a 16 H.P. undertype compound engine similarly fitted; a special first award for the "Essex" patent vertical boiler; and another special first award for an improved double cylinder winding and hauling engine. It will be noticed that the above awards are all "specials."

REMOVAL.—The offices of the Monte Video Telephone Company have been removed from 25, Abchurch-lane to 96, Gresham House, E.C.

ELECTRIC LIGHT INSTALLATION AT BOLTON TECHNICAL SCHOOL.—The electric light installation for the Bolton Technical School, which was formally opened on Saturday, March 19th, has been supplied and erected by Messrs. Ernest Scott and Mountain (Limited), of Newcastle-on-Tyne. There are two dynamos of the Tyne compound-wound type, fitted with heavy turned fly-wheels and fast and loose pulleys for generating the current, each machine giving an output of 90 amperes at an E.M.F. of 105 volts, when running at a speed of 900 revolutions per minute. The dynamos are driven by two 14 H.P. nominal Griffin gas engines, which have been supplied by Messrs. Dick, Kerr, and Co., of Kilmarnock.

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The total installation consists of about 220 16 c.p. incandescent lamps, the lamps being suspended by flexible pendants from the ceilings in the workshops. Where a concentrated light is required at any particular point the lamps are made to raise and lower, this being found a great advantage for weaving. In the lecture theatre arrangements have also been provided so that the current can be utilised for working the magic lanterns or microscopes, or for demonstrating the uses of electricity either as motive power or for chemical purposes. We may mention that the same firm has recently completed a large installation for the lighting of the printing works of the *Bolton Evening News*, and have also lighted up the Rothwell Hosiery Company's mills at Bolton.

THE NATIONAL TELEPHONE COMPANY.—The dinner to the staff of the National Telephone Company will be held this (Friday) evening at Anderton's Hotel, Fleet-street, E.C.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

March 2 1892.

4,157. H. W. TAYLOR. London. Improvements in shades for electric glow lamps.

4,158. H. EDMUNDS. London. Improvements connected with electric circuits for varying, regulating, or controlling the pressure of electric currents therein.

4,161. F. J. TAYLOR. London. Improvements in regulating the feed of arc lamps.

March 3, 1892.

4 185. P. STIENS. Manchester. A new or improved automatic portable galvanic battery.

4 186. S. J. ROLLASON. London. An improved slow-speed dynamo.

4,190. F. M. A. LAURENT-CELY and E. FINOT. London. Improvements in electrical batteries.

4,192. F. H. NALDER, H. NALDER, C. W. S. CRAWLEY, and A. SOAMES. Clerkenwell. Improvements in and relating to electric meters.

4,244. H. ENDALL. London Improvements in ship's telegraphs.

4,247. H. S. KEATING. London. An electrical cut-out.

4,248. J. BROCKIE. London. Improvements in arc electric lamps.

March 4, 1892.

4,258. W. L. SPENCE. Manchester. Improvements in the wearing parts of dynamo-electric machinery.

4,276. R. W. PAUL and F. KNOWL. London. Improvements in electrical testing instruments.

4,277. A. E. PATTERSON. Rotherhithe. An electric motor.

4,294. W. CROSS. London. Cross's electrical illuminations for clocks, &c.

4,311. W. S. SMITH and H. J. GARNETT. London. Improvements in dynamos.

4,316. E. G. HOFFMANN. London. Improvements in electric welding and in apparatus therefor.

4,320. A. W. MONEY and H. NASH. London. Improvements in apparatus for regulating the arc in electric arc lamps.

March 5, 1892.

4,341. W. L. SPENCE. Manchester. Improvements in the methods of driving electric railway trains.

4,356. W. T. GOOLDEN and S. EVERSHED. London. Improvements in electric measuring instruments.

4,403. W. K. PARTINGTON. London. An electric switch.

4,414. C. COERPER. London. Improvements in and relating to dynamo-electric machines.

4,416. W. H. WESTON and G. W. WESTON. London. Improvements in electric switches.

4,427. J. E. KINGSBURY. London. Improvements in switchboard systems for telephone exchanges. (The Western Electric Company, United States).

4,428. J. E. KINGSBURY. London. Improvements in switchboard systems for telephone exchanges. (The Western Electric Company, United States).

4,429. J E. KINGSBURY. London. Improvements in switchboard systems for telephone exchanges. (The Western Electric Company, United States).

March 7, 1892.

4,456. R. W. JAMES, London. A process for electro-plating. (G. E Gale, United States.)

4,457. R. W. JAMES, London. An apparatus for cleaning the hulls of vessels and other objects for electro-plating. (G. E. Gale, United States.)

4,458. R. W. JAMES, London. An electrode for electro-plating. (G. E. Gale, United States.)

4,464. H. B. LEE and J. C. COOK. London. An automatic electric loom and card-cutting machine.

4,494. F. V. ANDERSEN. London. Improvements in electro-magnetic solenoid apparatus.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

1,050. DE FERRANTI. Distributing electrical energy.

3,127. CRUYT. Electric circuits.

6,213. MARCUS AND OTHERS. Galvanic batteries.

6,247. JOHNSON. (Gendron.) Galvanic batteries.

21,541. PYKE AND HARRIS. Dynamo-electric machine in luctors.

1892.

406. AMERICAN ELEVATOR COMPANY. (Otis Bros. and Co.) Electric motors, &c.

576. FITZPATRICK (Electric Heat Alarm Company.) Electric heat alarm.

638. RABBIDGE. Telephonic switching appliances.

825. FAIRWEATHER. (Phillips.) Electric cables.

1,143. AMERICAN ELEVATOR COMPANY. (Otis Bros. and Co.) Electric elevators, &c.

1,147. NEWTON. (Rabbidge.) Telephones.

COMPANIES' MEETINGS & REPORTS.

Direct Spanish Telegraph Company (Limited).

The thirty-seventh ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on Tuesday, March 22, 1892, under the presidency of Sir James Anderson.

The MANAGER (Mr. Charles Gerhardi) read the notice convening the meeting and the minutes of the last meeting, which were confirmed by the present meeting, and signed as correct by the Chairman.

The CHAIRMAN: Gentlemen, I presume you will take the report as read, as it has been in your hands for some time; and I will therefore make a few supplementary remarks on each of the paragraphs in the order in which they occur in the report. The first paragraph is a matter of formal announcement. The second paragraph refers to a decrease in the receipts of £2,214. At previous half-yearly meetings I have foreshadowed that some such result was inevitable if the tariff was further diminished. I do not know of any authentic instance of a reduction of tariff leading to an increase of revenue until several years of commercial growth had elapsed. I have heard some vague statements to the contrary in regard to internal traffic, but I confess myself sceptical on the subject and for external or extra-European traffic it is not possible. There is no instance of such an occurrence; it is, in fact, an axiom in telegraphy that all reductions of tariff must result in a loss at the beginning. I have many times in writing and speaking reminded the public that it took 14 years for our Post Office to get back to the same gross revenue which they enjoyed prior to the introduction of penny postage, and more than 20 years before they got the same net revenue. The result of the penny postage is a favourite argument with advocates for reduced tariffs. We are all familiar with the results of great reductions upon our extended submarine cables both to the East and West. Such reductions have been bold and startling, and such as would, if anything could, have given an impulse to telegraphic traffic; and one would, therefore, have thought that the sacrifice would have been recouped with phenomenal rapidity; but such has never been the case. It has generally been a good deal disappointing, rising quickly at the beginning when the reduction is made, then languishing over a prolonged period until it reaches about the same amount originally expended with the higher tariff. You will find when you examine the different reports of the Companies that this statement is very near the mark. There is a certain amount spent on international telegraphy, and it takes a long time to get anything more out of the public, the process of recouping has been tedious as a rule. Naturally, however, if you reduce the tariff you broaden the basis from which telegraphy may grow, and you may in most cases gradually recoup your losses in a few years, always provided that the reduction has been such as to give a substantial impulse. But what can be said for our poor reduction of a halfpenny per word taken from this Company's proportion of 2½d. per word upon Spanish traffic? We only get 2½d. per word out of the 4d., or rather we used to, but now we only get 2d. per word upon our Spanish traffic, and the halfpenny per word which has been taken off has simply resulted in a loss to us of £1,760. A halfpenny per word can have no effect in retarding or increasing external telegraphic traffic. I do not know whether the tariffs will yet be further reduced, but we need not anticipate, and it is no use crying about it. We did all we could at the Telegraph Conference, and both our Post Office and the Spanish officials did what they could for us. Let us hope, now that the result is again shown, that they will not continue to reduce tariffs, and so make it impossible to maintain submarine cables by private

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enterprise. Paragraph 3 states that the working expenses are £17 in excess of those of the corresponding period of last year; but, as we have carried 7,800 more telegrams, containing 43,000 more words in that time, I need not detail the items. Salaries and stationery alone show an increase, every other item exhibiting decreases. I now come to paragraph 4, the cost of repairs. You will remember how fondly we cherished the idea of amassing a contingency fund when we talked about the matter a year and a-half ago. I then held out a rose-coloured hope that this might grow with our reserve, and help us to renew our debentures, as well as to reduce their amount in 1894. Well, gentlemen, all this contingency fund is gone, and £2,376 of our reserve in addition, for the purpose of repairing our cables. I may say that I have seldom known of a more fortunate repair than the one in question. Our Bilbao cable developed a bad fault at the end of last October, and in the month of November—one of our worst winter months—it was repaired in 1,900 fathoms near the Bay of Biscay. It was totally interrupted for only three days; but fortunately the Eastern Company had a ship at Lisbon, and did not lose an hour. I have known such repairs to require several months at that season. The problem for your Directors, however, is how to get back that £2,376 of our reserve. We say in the report that we hope to replace it out of future profits—a spendthrift way of looking at such expenditure, you may say, and so it would be but for the fact that the traffic is growing, and your Directors will not bind themselves to pay any given dividend if the traffic shall not warrant it; but we shall watch hopefully, and act as it shall seem to be warranted by the revenue. There seems to us to be an elasticity in Spanish traffic which encourages us to hope for good times, so far as telegraphy goes. Personally, I am trying to believe that the public find they cannot do without the telegraph; and at 4d. per word, with a three minutes' transmission to Bilbao nd 20 minutes to Madrid, if anything will stimulate enterprise such facilities ought to do so. With regard to paragraph 5, there has been some exceptional expenditure amounting to £626. The French Government decided to shift their telegraph office at Marseilles, and we, as well as the Eastern Company, had to follow. The expense of new underground wires will, of course, be heavy, and we had to do a good deal of similar work at Falmouth and Bilbao. I sincerely hope I may have something more encouraging to say at our next meeting. We have a growing traffic, and can only work and watch. If we can be free from repairs, and the Telegraph Conferences will let our poor halfpennies alone, I see no reason for anxiety. I hope before the next Conference comes nearer hand that we shall be able to influence our Government and the different administrations of the European States not to touch these low tariffs. It does not do any good at all. Fourpence per word is nothing in an international telegram, and the worst of it is that we only get twopence out of this fourpence, and the wretched halfpenny off the 2½d. which we used to receive has lost us all this money. I do not know how these cables are to be kept up unless there is a suspension of further decreases of the tariff. If a State chooses to subsidise lines, and make losses, they can, by taxing the community, make up any loss they like. We, however, cannot tax anyone, and we only look forward to being able to do the best we can by appeal, agitation, and entreaty, but we can do no more. I now beg to move:—

"*That the reports and accounts now presented be and are hereby received and adopted.*"

Mr. EDMUND ETLINGER seconded the motion.

The CHAIRMAN: Before I put the resolution I shall be very happy to answer any questions if any shareholder is desirous of asking any. No shareholder rising to address the meeting, he put the motion in the usual way, and having declared it carried unanimously, said: The next resolution is—

"*That the dividend at the rate of 10 per cent. per annum (less income tax) on the preference shares, and a dividend at the rate of 4 per cent. per annum (free of income tax) on the ordinary shares, both for the half-year ended December 31, 1891, be and are hereby declared.*"

Mr. ETLINGER seconded the motion.

The CHAIRMAN put the resolution in the usual way, and it was carried unanimously.

Mr. ETLINGER: The two Directors who retire by rotation are Sir James Anderson and Mr. Denison Pender; and I beg to propose the following resolution:—

"*Resolved, that Sir James Anderson and Mr. J. Denison Pender be and are hereby re-elected Directors of the Company.*"

Mr. DAVID LOWE seconded the motion, which was carried unanimously.

The CHAIRMAN: For myself and my colleague, Mr. John Denison Pender, I beg to thank you; and I think I ought at this point just to say how much I appreciated the kind resolution of sympathy with me which you passed at the last meeting.

Mr. DAVID LOWE proposed:—

"*That Mr. Herbert R. Duke be and is hereby re-elected auditor for the present year, with a remuneration of 20 guineas.*"

Mr. KENNETH ANDERSON seconded the motion, which was unanimously carried.

The CHAIRMAN having intimated that that was the whole of the business,

Mr. COCHRANE said he thought that, although the report was rather discouraging, they ought not to separate before thanking the Directors for the way in which they looked after the interests of the shareholders. He therefore proposed a cordial vote of thanks to the Chairman and Directors.

Mr. CREASEY briefly expressed his pleasure at seconding the motion.

The resolution was carried unanimously.

The CHAIRMAN: We are all much obliged to you. We cannot make things better than they are, unfortunately, and 2d. is a dreadful little tariff to get for this work. It is not a very encouraging result that we present, and yet, after all, it is not disheartening, because I hope that we have got to the ground-floor of the tariff. If so, I do not fear the result. If, however, the tariff goes lower, we shall have to tell you about it. I am extremely obliged to you for your confidence.

The proceedings then terminated.

The Electric Construction Corporation (Limited).

An extraordinary general meeting of this Company was held at Worcester House, Walbrook, E.C., on Tuesday, March 22nd, for the purpose of considering, and, if thought fit, confirming as a special resolution, the resolution which was duly passed at the general meeting held at the same place on March 3rd for increasing the capital of the Company. Also for the purpose of considering, and, if thought fit, passing further resolutions having reference to the mode of issue of such capital. Mr. J. S. Balfour, M.P., presided.

The SECRETARY (Mr. W. Samson) read the notice convening the meeting.

The CHAIRMAN: Well, gentlemen, my first duty is to move a resolution confirming the resolution of the 3rd day of March, 1892, viz.:—

"'*That the capital of the Company be increased to £750,000 by the creation of 25,000 new shares of £10 each, numbered 50,001 to 75,000 inclusive,' be, and the same is hereby confirmed.*"

I presume that most of the gentlemen who are present to-day were present also at the general meeting which was held on the 3rd March, and I need not therefore trouble you with any statement at any length as to the reasons which have induced the Board to advise that this increase of capital should be made. You are aware that the business of the Corporation has increased in the most satisfactory manner, and that we are informed by our Works Director that the works are quite full, and there is every reason to anticipate, if we increase the capital, that we shall be able to take some very large and very lucrative contracts. All this was stated at the previous meeting, and the resolution for increasing the capital was unanimously approved at that meeting. I now move that the resolution be confirmed. Mr. Courtenay will second it.

Mr. COURTENAY: I beg to second the resolution.

The resolution was unanimously carried.

The CHAIRMAN: We now come, gentlemen, to the mode of issuing this capital, and the resolution which I have now to read is one which has been drawn up by our solicitors, and it is as follows:—

"*That one-half of the said new shares, being those numbered 62,501 to 75,000, inclusive, be allotted and issued by the Directors to such persons and at such times as the Directors shall think proper, and that the said shares shall be preference shares, and shall entitle the holders thereof to a cumulative dividend at the rate of 7 per cent. per annum on the amount credited as paid up thereon, in priority to any dividend on the ordinary and founders' shares of the Company.*"

This proposal has met with the approval of the founders; and that, I think, is probably the best evidence that it is to the advantage of the Company. I may state what is present to the mind of the Board is that at the present moment we probably shall be able to raise, in fact we have at the present moment offers to subscribe for, a considerable portion of this preference capital; we believe we could raise something of this amount, not probably so much as the whole £125,000 (we do not want to raise so much as that at present), but £50,000, £60,000, or perhaps £75,000 of preference capital, we could raise that, and use it to very great advantage indeed. We believe that the probable claims upon capital, so far as we can foresee, will be met by £125,000 of additional capital. We think when that is raised that by that time the ordinary shares will be at a premium, and we have every reason to believe that we ought to be able, certainly with the business which we have in view, to put a premium, if we want to, upon any additional capital we may be able to raise by means of ordinary shares, and that premium will go to the reserve fund. You will observe in the resolution that it is stated that these shares shall be issued and allotted by the Directors to such persons as the Directors may think fit. Of course, the Directors consider themselves bound by the terms of the prospectus, and by all the assurances they have ever given to the ordinary shareholders, to offer these shares in the first instance to the ordinary shareholders, so that every ordinary shareholder shall have an opportunity of acquiring some of these preference shares if he so thinks fit. Having carefully considered the matter, the Directors believe that this is the most likely mode in which the capital, which is so urgently required, can be raised, and which does not exceed £75,000, but which I think will not probably exceed £60,000. We think this the best mode of doing so, and we have taken the best advice we could get from brokers and others in the City of London; and everybody seems to think—and we have evidence that it will be so—that these shares will be taken up, by the fact that several of the Directors and the shareholders have expressed their willingness to subscribe for much more than their proportion. We shall offer the shares we issue to the ordinary shareholders in proportion to their holdings, and if they take them up I think they will secure a very good investment indeed. I move this resolution, which will also be seconded by Mr. Courtenay.

Mr. COURTENAY seconded the resolution, which was unanimously carried.

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Mr. ROWE: I should like to ask, Sir, whether you propose—supposing you issue a part of these shares—whether you propose to call them entirely up or to issue the remaining portions? Now I think it much better to call up each portion as it is issued.

The CHAIRMAN: Hear, hear.

Mr. ROWE: Because the shares will get more valuable if they are called up. There is always great anxiety about shares if a large call can be made upon them; and therefore I should urge—suppose half of them are allotted now—that these should be called up before the whole are issued. As to another matter you have touched upon, I agree that the shareholders should have a chance of taking up this capital.

The CHAIRMAN: Hear, hear.

Dr. DRYSDALE: I suppose we have to vote upon this question upon the supposition, which is perfectly clear from what you have stated, that we may expect greater dividends in the future—I do not say you commit yourselves to that—but I presume you mean that the dividends are likely to be more than they have been, because otherwise it would be a pity to borrow money at 7 per cent. and to give only 6 per cent. That is the only point upon which I desire information.

The CHAIRMAN: Yes, of course; we are large shareholders ourselves, very large holders of ordinary shares. I myself am a very large holder of ordinary shares, and I should not like to see capital put before mine if I did not think that it would be to the benefit of the ordinary shareholders. I cannot conceive with these contracts we have in view and those immediately in hand—if we obtain these orders—I cannot conceive but that there will be a considerable ultimate increase in the dividend to the ordinary shareholders. With regard to the question asked by Mr. Rowe, of course our intention is to call up the shares in full which are issued at present; to make the calls fairly easy, of course, but to call the shares up in full. I agree with Mr. Rowe that it would not be desirable to have preference shares issued with a considerable liability upon them; and, looking at the present day and at the present condition of the Money Market, it is really better to have as little liability on shares as possible. I think prudent investors prefer to make their payments at once, and get rid of the liability. If there are no other questions to be asked I will put the resolution. Those in favour of the resolution please signify in the usual way. On the contrary. It is carried unanimously. Then the next resolution is:—

"*That the said preference shares shall also entitle the holders thereof, upon a return of capital of the Company, to be repaid the amounts credited as paid thereon, before any payment in respect of capital is made on the ordinary and founders' shares of the Company.*"

Mr. Courtenay will second that.

Mr. COURTENAY seconded the resolution, which was unanimously carried.

The CHAIRMAN: That, gentlemen, concludes the business of the meeting, and I thank you very much for your attendance. There will be a confirmatory meeting held on Thursday, April 7th, but it is only *pro formâ*, and notice of it will be duly sent out to you.

A vote of thanks to the Chairman for presiding closed the proceedings.

The Gülcher (New) Electric Light and Power Company (Limited).

The fourth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, London, on Monday last; Mr. D. De Castro, Chairman of the Company, in the chair.

The SECRETARY (Mr. T. C. Morgan) having read the notice convening the meeting, and the minutes of the previous meeting having been confirmed,

The CHAIRMAN said: Gentlemen, I dare say you have all read the report and balance-sheet, and I wish to say that, if any shareholder would like a copy of the manufacturing and profit and loss accounts, it lies on the table, and the perusal of these accounts will enable any shareholder, if he so choose, to criticise them when the proper time arrives. In adopting this course, we are following the precedent of last year, and we are following the statutes enacted for the purpose of regulating joint-stock companies. The reason for postponing the meeting so long was that it took some time after my return to England to interpolate the New Zealand accounts into the general accounts of the Company, and it took some further time to make myself master of the general position of the business. Hence the delay. As you are aware, I went to New Zealand in December, 1890, in order to get some private Bills through the Colonial Parliament; and I am happy to say that we have obtained one Bill for Wellington, one for Christchurch and one for Auckland. I believe the first two are of very great value. As to the Auckland one, I think it too will become valuable in time, but in Auckland the gas interest was rather too strong for me, and I was obliged to make a compromise. I felt that, rather than risk the loss of two valuable Bills already obtained for the sake of getting a third, I would consent to the third being reduced in value. You know, gentlemen, the difficulty that we were plunged into some four years ago, on entering into a contract for the lighting of the City of Wellington. Our late Manager, rightly or wrongly, made a tender to light, as he thought, three miles of streets. As a matter of fact, we have lighted the streets of a city three miles long. Mr. Mountain estimated that the contract would cost us £2,500; but it gradually grew, as you recollect, to £3,500, to £4,500, and finally it reached £14,500. We managed to find the £14,500, and although, as stated in the report, the income from public lighting was only £1,750 per annum, reduceable in three years to £1,600 per annum, while it cost the Company nearly £1,300 per annum to maintain; yet the contract was, on account of the private lighting clauses contained in it, of considerable value, provided Parliamentary powers could be obtained to authorise private supply. It was resolved, therefore, that I should go out to obtain such Parliamentary powers if possible. Another reason for sending me to New Zealand was that serious litigation with the Corporation of Wellington was threatened, which it was most desirable to avoid. At the end of the first year's working the Corporation thought that they had a claim to be paid a sum (amounting to about £530 per annum) on account of water which they alleged that the Company used in excess of what the Corporation had contracted to supply, and they deducted this sum from the £1,750 which they ought to have paid us. This was a very serious matter, as it made the public lighting contract an absolute loss. Lastly, the working of the contract was necessarily extravagant from the fact that the current was supplied from two central stations nearly a mile apart, involving the maintenance of two sets of drivers, stokers, and attendants. Well, gentlemen, to cut a long story short, I have managed to concentrate the two stations into one, and to reduce the working expenses by more than one half. I have arranged the dispute with the Corporation, and made an entirely new contract with them; and whereas the public lighting contract was producing, at best, £300 per annum, it is now producing upwards of £1,200 per annum net.

Major COTTON: Net? And since when?

The CHAIRMAN: Since October 1, 1891. It will come into next year's accounts. Having got my three Acts of Parliament as above stated, and made the arrangements and contracts I have just sketched out, I cannot help feeling that my journey has been a very great success, and I trust that from the New Zealand Electrical Syndicate, in which we are very largely interested, we shall derive a very great benefit. With regard to the loss during the past year shown in the balance-sheet, this is distinctly traceable to the depression which fell upon business in England after the failure of Messrs. Baring's house. For the first time during the last nine years our year's receipts from sales in England have decreased; and, during our financial year 1890-1891 they decreased by £2,500, while the business in New Zealand was temporarily at an enforced standstill. You will see, gentlemen, if you refer to the accounts before you, that on the credit side of the profit and loss account, we take credit, not only for the sales and hire of dynamos and lamps in England, but also in New Zealand. The sales in England are rather less than they were during the preceding 12 months. I can find no reason for it except that orders generally fell off during the last three months of 1890 and the first six months of 1891. They began to increase again during the last six months of 1891; and I attribute this falling off during the first nine months partly to the blight which fell upon business generally all through England last year, and partly to the enforced stoppage of our business in New Zealand under the circumstances mentioned to you. We could not do anything over there, when the funds which belonged to us were kept in the hands of the Corporation. Taking into consideration these two facts, I think it is not to be wondered at that the Company did not do quite so much business as in the preceding year. Since June, 1891, the sales in England have again improved. An agency has been opened in Italy, and a new field has been opened in the colony of New Zealand which promises to be a large and permanent customer of the Company. This is, perhaps, a convenient point at which to tell you more in detail what has been done in New Zealand. (Here the Chairman went at length into the details of various businesses done and contracted for in New Zealand and other Australasian Colonies by him during his absence.) Subsequently, referring to the accounts, he said the balance sheet is very much in the same form as it was the last time I had the pleasure of meeting you. There is a total preference share capital paid up of £36,497. 11s. 4d., with £178. 8s. 8d. unpaid calls. The first debentures remain at £8,000, bearing interest at £6 per cent., while the whole of the £10,000 £10 per cent. debentures have been paid off except £500, which will be discharged in February, 1894. After discussing various items in the accounts and answering various questions by shareholders the Chairman moved the adoption of the Report and the passing of the accounts placed before the meeting.

Mr. HENRY GRÈWING seconded the motion.

Mr. STUDD thought that every shareholder in the room would desire to convey his congratulations to Mr. De Castro upon his being with them again, after his journey to the antipodes, of which he had given so interesting an account. He trusted that all Mr. De Castro's hopes might be realised. After discussing the accounts he asked whether the Directors had considered the propriety of following the example of the Brush and other electrical companies who had amalgamated with engineering firms, and had increased their business in that direction.

The CHAIRMAN said Mr. Studd had suggested an amalgamation. That had been his own desire for several years, and if the Directors could see their way to such an amalgamation they would be very glad to consider it. He had already tried it once, but without success. After further discussion, in which Major Cotton, a large shareholder, took part, the report and accounts were agreed to.

On the motion of Mr. STUDD, seconded by Major COTTON, the retiring Directors, Mr. Grèwing and Captain Levett, were re-elected; and, on the motion of Mr. LAMONT, seconded by Mr. BINSWANGER, Mr. Russell Day was re-elected auditor.

The CHAIRMAN then having intimated that the business of the meeting was at an end, Mr. STUDD moved, and Major COTTON seconded, a vote of thanks to him; and the meeting terminated.

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The London Electric Supply Corporation (Limited).

The following annual Report of the Directors of this Corporation has just been issued. The meeting of shareholders will be held at Cannon-street Hotel, E.C., to-day (Friday), at 12 o'clock.

The Engineer's Report appended hereto describes in detail the general position of the works.

The result of the year's working was adversely affected by the fire which took place at the Grosvenor distributing station on November 15, 1890, which caused an entire cessation of the lighting for a space of three months. After supply was resumed on February 16, 1891, it was found that many of the Corporation's old customers had resorted to other companies. Although a considerable amount of new business has been gradually acquired, it was only towards the end of the year that the number of lights installed equalled those connected at the time of the fire. Advantage was taken of this interruption to business to reorganise the system of distribution. The whole of the overhead cables were removed and concentric underground cables substituted; at the same time the distributing mains were extended to many districts in the authorised area of supply which had not previously been touched, and where there is good prospect of remunerative business being obtained.

The extension of electric lighting generally has been less rapid than was anticipated, but the light is undoubtedly growing in public favour. The greatly improved supply now given by the Corporation gives reason for anticipating a material increase of business during the current year.

As referred to in the Engineer's Report, measures are being taken by which the cost of producing the current will be very materially diminished, and the efficiency of the generating plant increased.

During the year the engagement of Mr. de Ferranti has ceased by effluxion of time. Mr. P. W. D'Alton, the chief assistant to Mr. de Ferranti during the construction of the generating station, has been appointed chief engineer. The Directors retiring, as provided by the Articles of Association, are Mr. James Staats Forbes and the Hon. Reginald Brougham, both of whom are eligible for re-election. The auditors, Messrs. Kemp, Ford & Co., who retire in accordance with the Articles of Association, offer themselves for re-election.

The following is the Engineer's Report above referred to:—

"At the commencement of the year 1891, owing to the fire at the Grosvenor Station in November, 1890, when much of your transformer plant and other apparatus was destroyed or seriously damaged, your Central Station at Deptford was supplying no current. When supply was resumed on the 16th February, 1891, only 9,000 lights were at once installed, and the number gradually increased to 36,000 by the end of the year.

"In the interval the two dynamos, each of 625 H.P., were removed from the Grosvenor Station and erected at Deptford, with two new tandem compound horizontal engines. Until August last these dynamos furnished the supply unassisted; the current, generated at 2,400 volts, being transformed up to 10.000 volts, and at that pressure transmitted to the distributing stations in London.

"The two dynamos, each of 1,250 H.P., which, prior to November, 1890, had supplied current direct to the mains at a pressure of 5,000 volts, were, during the latter end of 1890 and the early part of last year, altered to generate current at 10,000 volts. An unsuccessful attempt to run one of them was made towards the end of July, but they were not ready for work until August 10th, about which time I took over the duties of engineer-in-chief. Since then all these machines have been in work, the larger ones generating current at 10,000 volts.

"During the past autumn considerable difficulties were experienced in working the 10,000 volts system, and there were occasional failures of the dynamos, high-tension transformers, and trunk mains, many of which were due to the present arrangements for working the machines in parallel. Unfortunately, these failures have caused interruption of supply on several occasions; but measures have been, or are now being taken, by which it is believed these difficulties will be overcome. For the last four months there has been great improvement, and breakdowns have been of very rare occurrence.

A number of faults occurred in the trunk mains during the year, but they are now causing us less trouble and anxiety. I am of opinion that such faults are more or less inseparable from any new system, and that they will eventually be eliminated. During the first four months after the resumption of supply the failures were numerous; during a second similar period they diminished to less than half, and latterly they have been gradually ceasing.

"Similar troubles were experienced with the high-tension transformers, but as the year advanced the failures became less frequent, owing to careful repairs, and during the last four months we have had but one failure.

"A few months since we established at Deptford a new department, where we repair transformers and make various parts of machines for maintenance and renewals. The work already turned out by the department is equal to anything we have had done by outside contractors, and superior to most of the work supplied to us; at the same time a considerable saving in money is effected, and work is more promptly done.

"The work on the 10,000 H.P. dynamos was suspended in May last by your order, but the parts of the machines have been properly protected and are in good condition.

"The distributing mains have been greatly extended during the past year, and, as there are now upwards of 27 miles laid, a large increase in the volume of business may reasonably be anticipated. They are in a thorough state of efficiency, and have caused but little expense for maintenance or repair.

"The permanent switching gear is now being erected at the distributing stations, and will shortly be completed. At two of the stations it is already in use and is working satisfactorily.

"The engines and boilers have been kept in good working order. The two sets of generating plant of 625 H.P. cannot be worked to their full capacity owing to faulty design, in consequence of which it is impossible to produce a larger output than 8,500 to 9,000 lights from each. This defect is about to be remedied to a considerable extent at a moderate outlay.

"A scheme for condensing the exhaust steam has been approved by you, and I am getting forward with the preparations for the work. When completed, which I hope it will be by July next, it will greatly improve the running of the engines, and will have the effect of saving at least 25 per cent. of the consumption of coal.

"P. Walter D'Alton, Engineer-in-Chief.

"Stowage Wharf, Deptford, March 10, 1892."

The Engineer's Report is followed by a note from Dr. Fleming:—

"I have read the Report of your Chief Engineer, and, having been associated with him as your scientific adviser in the working of the system during the past year, I generally concur in that Report.—J. A. Fleming, M.A., D.Sc., University College, London, March 11, 1892."

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "The Electrician" Electrical Trades Directory and Handbook, 1892, pages 308-322, *&c., &c.*]

ASSAM-BENGAL RAILWAY COMPANY (LIMITED).—This Company was registered on March 18, 1892, with a capital of £1,500,000, in £10 shares, by Freshfield and Williams, 5, Bank-buildings, E.C. Among the objects is included that of purchasing, taking on lease or otherwise acquiring, working, and turning to account telegraph and telephones, and "to carry on in all their respective branches all or any of the businesses of manufacturers of engines and all kinds of rolling stock, mechanical engineers, electrical engineers, electricians, manufacturers and purveyors of electricity for the purposes of light and power," &c.

CHANNEL TUBULAR RAILWAY PRELIMINARY COMPANY (LIMITED).—This Company was registered on the 17th inst. with a capital of £40,000, in £4 shares, by W. Wills, Broadway Chambers, Westminster, S.W. The objects are to acquire the patents or rights to use and exercise the patents, concessions, rights and business of the submerged tube system of railway between England and France (Sir E. J. Reed's patent), and to take all necessary preliminary steps required for the construction of a tubular railway through the Straits of Dover as a means of communication by steam or electric locomotion.

ELECTRIC LIGHTING AND GENERAL DEVELOPMENT SYNDICATE (LIMITED).—This Company was registered on March 21, 1892, with a capital of £700, in £10 shares, by C. W. and H. B. Taylor, 31, Crutched-friars, London, E.C. The objects are to acquire, by grant, purchase, transfer, lease, hire, or otherwise, from any sovereign government, corporation, municipality, authority, or otherwise, concessions, licences, grants, decrees, rights or privileges, public and private, and to exercise, manage, carry on, promote or form in any part of the world, any business, undertaking, company, or trade, in pursuance of any such concessions, licences, &c. The number of Directors will be as far as possible kept to not less than three, the first being William Warriner, E. J. Rhodes, and George Morison. Remuneration, £2 per cent. upon whatever net profits are divided by the Directors among the shareholders. Registered office: 31, Crutched-friars, London, E.C.

MERRYWEATHER AND SONS (LIMITED).—This Company was registered on March 22, 1892, with a capital of £110,200, divided into 6,000 £6 per cent. preference or "A" shares of £10 each; 200 management or "B" shares of £1 each; and 5,000 ordinary, or "C" shares of £10 each, by Peake, Bird, Collins, and Peake, 6, Bedford-row, W.C. The objects are to enter into and carry into effect an agreement between James C. Merryweather of the one part, and the Company of the other part, and to carry on in the United Kingdom or elsewhere, the manufactures, trades and businesses acquired under the said agreement, including that of fire engine manufacturers, fire escape manufacturers, hydraulic engineers, electrical engineers, general engineers, pump-makers, hose-makers, coppersmiths, boiler-makers, makers of all classes of fire-extinguishing appliances, and other allied businesses carried on by the said J. C. Merryweather at London, Greenwich, and elsewhere, under the style of "Merryweather and Sons." The number of Directors is not to be less than three nor more than seven, the first being J. C. Merryweather (the "governor"), A. Essex, E. P. Williams, C. J. W. Jakeman, and L. Miller.

NEWPORT METAL STAMPING COMPANY (LIMITED).—This Company was registered on the 21st inst., with a capital of £3,000, in £50 shares, to carry on the business of mechanical and electrical engineers, iron workers, brass founders, tin stampers, lamp manufacturers, &c.

EASTBOURNE ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of the above-named Company, made up to November 8, 1891, was filed on February 25, 1892. The Company was registered on February 15, 1882, with a capital of £50,000, in £10 shares. At the time of making up, 1,017 ordinary and 40 preference shares had been taken up, the full amount called, and all calls (£10,570) paid.

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ELECTRO-CHEMICAL SYNDICATE (LIMITED).—The following letter has been received by the Registrar of Joint-Stock Companies:—"The Electro-Chemical Syndicate (Limited) *did not go to allotment*, and has never transacted any business." The Company was registered on October 16, 1890, with a capital of £5,000, in £1 shares, and has never filed any returns.

ELIESON ELECTRIC COMPANY (LIMITED).—A letter has been received from the late secretary (T. P. Gower) of the above-named Company, stating that the Company "has ceased to carry on business for two years past."

INTERNATIONAL ELECTRIC SUBWAY COMPANY (LIMITED).—The registered office of the International Electric Subway Company (Limited), formerly at 43, Threadneedle-street, London E.C., is now situated at Albany Buildings, 39, Victoria-street, Westminster, S.W.

LAURENCE, SCOTT AND COMPANY (LIMITED)—The annual return of the above-named Company, made up to January 6, 1892, was filed on March 7. The Company was registered on August 10, 1868, with a capital of £30,000, in £10 shares, under the title of "Laurence, Paris and Scott (Limited)." At the time of making up, 1,205 shares had been taken up, of which 300 had been issued as fully-paid as part of the purchase consideration. Upon the remaining 905, the full amount has been called and all calls have been paid.

MEXICAN GAS AND ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of the above-named Company, made up to December 23, 1891, was filed on March 9. The Company was registered on April 24, 1883, with a capital of £100,000 in £20 shares, to acquire the exclusive privilege of lighting the capital of Mexico, and the cities of Puebla, Orizaba, Cordova, and Jalapa, in the Republic of Mexico. At the time of making up, all the shares had been taken up, and all were issued as fully paid, in full satisfaction of the purchase price. Of the 5,000 shares, A. O. H. Gibbs, of 15, Bishopsgate-street Within, London, E.C., holds 4,994. Registered office: 15, Bishopsgate-street Within, London, E.C.

NEW TELEPHONE COMPANY (LIMITED).—The following notice was filed on February 22, 1892:—"At an extraordinary general meeting of the New Telephone Company (Limited), duly convened and held at 147, New Bond-street, London, on January 26, 1892, the subjoined special resolution was duly passed, and at a subsequent extraordinary general meeting, also duly convened and held at 3, Carlton House-terrace, London, on February 16, 1892, the subjoined special resolution was duly confirmed:—'That the Bill submitted to the meeting, entitled "A Bill to provide for dissolving the New Telephone Company, and for re-incorporating the Company, and defining its capital, objects, and powers," be, and the same is hereby approved, subject to such additions, alterations, or variations, as Parliament may think fit to make therein, and the Directors shall sanction.' Signed Marlborough, Chairman."

NORTHERN ELECTRIC WIRE AND CABLE MANUFACTURING COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 24, 1892, was filed on March 8, 1892. The Company was registered on June 25, 1889, with a capital of £20,000, divided into 660 vendors' and 3,340 ordinary shares of £5 each. At the time of making up, all the vendors' and 1,512 of the ordinary shares had been taken up, of which the vendors' shares had been issued as fully paid. Upon the remaining 1,512 ordinary shares £2. 10s. per share had been called, resulting in the payment of £3,777. 10s., and leaving £2. 10s. per share unpaid.

ORIENT ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above-named Company, made up to December 31, 1891, was filed on March 16, 1892. The Company was registered on November 29, 1887, with a capital of £5,000, divided into 20 shares of £250 each, to engage in preliminary investigations and negotiations in India, Burmah, and elsewhere, with a view of initiating a business on a large scale for the application of electricity for lighting and other purposes, and to carry on in the United Kingdom, India, Burmah, Ceylon, and elsewhere, the business of electricians, mechanical engineers, suppliers of electricity and manufacturers of and dealers in electrical apparatus. Thirteen of the 20 shares have been taken up, £100 called on each share, and all calls paid. Registered office: 2, East India-avenue, Leadenhall-street, London, E.C.

PLANET ELECTRICAL ENGINEERING COMPANY (LIMITED).—The annual return of the above-named Company, made up to December 31, 1891, was filed on January 12, 1892. The Company was registered on March 26, 1889, with a capital of £20,000 in £5 shares. At the time of making up (December 31, 1891), 2,757 shares had been taken up, of which 800 had been issued as fully paid. Upon the remaining 1,957 shares the full amount had been called, resulting in the payment of £9,535 and leaving £250 in arrears.

PORTLAND ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 14, 1892, was filed on January 21st following. The Company was registered on November 30, 1887, with a capital of £45,000, in £5 shares, to enter into contracts for electric lighting and for the supply of electrical energy. At the time of making up, seven shares had been taken up, the full amount called, and all calls (£35) paid. No agreements for the acquisition of any contracts, business, plant, &c., have been filed.

CITY NOTES, &c.

ANGLO-CANADIAN ASBESTOS.—A dividend of 20 per cen for the year 1891, free of income-tax, has been declared by the Directors of this Company, being the same as for 1890.

A. AND J. STEWART AND CLYDESDALE.—At the annual meeting of the shareholders of this Company on Monday a dividend of 10 per cent. for the half-year, equal to 9 per cent. on the whole year, was declared, against 12½ per cent. last year. The difference was said to be due to the higher rate of labour, and to the fall in prices obtained for their production. The net profits for 1890 were £97,210, whereas last year they were £85,460, being a difference of £11,750. Depreciation now stands at £65,567. £4,000 was voted as Directors' fees for this and last year.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED). (Four and a-Half per Cent. Perpetual Debentures).—Letters of allotment and regret have been posted.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended March 20th were £897, as against £767 in the corresponding period of last year, showing an increase of £130. The total receipts to date, from January 1, 1892, are £9,727, against £8,481 for the corresponding period of 1891, an increase of £1,246.

COMMERCIAL CABLE COMPANY.—The following synopsis of the Directors' report, which was submitted and adopted at the annual meeting in New York on the 21st inst., has been published:—The year's earnings amounted to $1,904,717; the working and other expenses for the year amounted to $819,392, leaving a balance of $1,085,325. Dividends of 1¾ per cent. each were paid for the quarters ended March, June, September, and December, being a total of 7 per cent. on the capital stock of $7,716,000, and absorbing $540,120. The balance of the year's profits, amounting to $545,204, together with $29,796 from the profit and loss account of 1890, aggregating $575,000, was transferred to the reserve fund. On January 15, 1891, debenture bonds were redeemed to the amount of $600,000, and provision was made for the redemption of $600,000 of bonds on January 15, 1892.

PACIFIC TELEGRAPH COMPANY (LIMITED).—The subject of the laying of a Pacific cable has from time to time been mooted, and it may be interesting at this juncture to set out particulars relating to the Pacific Telegraph Company (Limited), which was registered in November, 1886, with a capital of £2,000,000 in £10 shares, to establish, make, maintain, work, and use telegraphs, telegraphic, telephonic, or other communication, submarine and overland, in and between Australia, New Zealand, and other islands and places in Australasia or the Pacific Ocean, Africa, America, Europe, or any of them; to enter into, make and fulfil any contracts or arrangements with the Imperial Government of the United Kingdom, or any Foreign or Colonial Legislature or Government, or other public authority, relative to the construction, acquisition, letting, hiring, use or working, of any telegraphs, or other communication used, or intended to be used, in connection with the objects or purposes of the Company. The subscribers to the Memorandum and Articles of Association were the Earl of Miltown, Sir James Corry, Bart, M.P.; Sir Daniel Cooper, Bart.; Viscount Folkestone, M.P.; Hugh G. Reid, J.P.; Sir Alfred Slade, Bart.; J. Henniker Heaton, M.P.; C. M. Young (banker), Captain E. Palliser, Randolph C. Want, W. J. Clarke, P. Perkins of Brisbane, S. Wilson, Murray G. G. Finch Hatton, and George Coote, F.S.I., and each of the above took one share in the Company. The number of the Directors was not to be less than three nor more than nine, the first to be appointed by the subscribers, and until such appointment the subscribers themselves were to act. The first registered office was situate at 34, Clement's-lane, Lombard-street, E.C. The last return made up to April 23, 1891 (filed on May 20, 1891), shows that out of a capital of £2,000,000 18 £10 shares had been taken up, and the full amount called, resulting in the payment of £130, and leaving £50 in arrears. The following are the only shareholders, each holding one share:—

Countess of Miltown, 2, Buckingham Gate.
Sir J. P. Corry, Bart., Dunraven, Belfast.
Sir D. Cooper, Bart., 6, De Vere-gardens, London.
The Earl of Radnor, 8, Ennismore-gardens, London, S.W.
H. G. Reid, J.P., Warley Hall, near Birmingham.
J. Henniker Heaton, M.P., 36, Eaton-square, S.W.
E. M. Young, 21, Palace-gate, Westminster, banker.
Major Edward Palliser, 91, Earl's Court-road, S.W.
R. C. Want, 32, Victoria-street, S.W., solicitor.
Sir W. J. Clarke, Bart., 27, Queen's-street, Melbourne.
The Hon. J. Perkins, Brisbane, Queensland.
Sir S. Wilson, M.P., Grosvenor-square, W.
The Earl of Winchilsea, Haverholme, Sleaford.
G. Coote, Smeetham Hall, Sudbury.
Sir Donald Smith, K.C.M.G., 88, Cannon-street, E.C.
Sir Sandford Fleming, C.M.G., Ottawa, Canada.
Owen Jones, Esq., Thatched House Club, St. James's-street.
Arthur Blackwood, Melbourne Club, Melbourne, merchant.

No agreements of any kind have been entered into. Present registered office unknown.

ROCKHAMPTON (QUEENSLAND) GAS AND COKE COMPANY (LIMITED).—In the report of this Company for the seven months ended December 31st last the Directors state that "Since the last general meeting a definite step has been taken in the matter of the electric light. After careful consideration it was decided to instruct the Company's London agents to invite applications for the position of electrical engineer to the Company; and out of a large number of applicants, Mr. A. E. Neal, of Birmingham, was selected. He has reported on the systems of electric lighting most suitable for Rockhampton. As the early introduction of the electric light will be advantageous to the Company in a variety of ways, the Directors have decided to proceed with it without delay, and have accordingly purchased a quarter of an acre of land in Alma-street,

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between William and Denham streets, for the erection of the works. Upon the frontage of this site, general offices and show-rooms will be erected for the convenience of the numerous customers in both sections of the Company's business, and the Directors are strongly of opinion that the removal of the offices to a more central position than the present one will be conducive to an increase of business. The Directors have undertaken to supervise, through the electrical engineer, the electric light operations at the Mount Morgan Gold Mining Company's works." The Company pays a dividend of 10 per cent., free of income tax, and carries forward £16. 16s. 9d.

STOCK EXCHANGE.—The following have been placed by the Committee of the Stock Exchange for quotation in the Official List:—Elmore's French Patent Copper Depositing Company's vendors' shares, Nos. 66,751 to 100,000; and General Hydraulic Power Company's additional shares, Nos. 60,001 to 70,000.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the fortnight ending March 15, 1892, amounted to £2,908, as compared with £2,986 in the corresponding period of last year, a decrease of £78.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ending March 18, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,181.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, March 16.	Price Wednesday, March 23.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending March 23. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	16/0	Anglo-American	49½ 50½	49½ 50½	4 19 0	Jan., Apr., July, Oct.	50¾	49½
£2,849,510	Stock	32/0	Do. Preferred	88½ 89½	88½ 89½	5 17 4	" "	89½	88½
£2,849,510	Stock	5/0	Do. Deferred	12 12½	11¾ 12¼	.. ..	" "	12¼	11⅞
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	10¾ 11¼	10¾ 11¼	7 2 3	Mar., June, Oct., Dec.	11 1/16	11 1/16
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104 108	104 108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock xd	151 156	151 156	4 9 9	Jan., Apr., July, Oct.	156	..
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3⅛ 3⅜	3⅛ 3⅜	6 18 8	April and October	3⅜	..
6,000	5	10%	Do. Preference 10%	8½ 9½	8½ 9½	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11½ 11⅝	11½ 11⅝	6 3 4	Jan., Apr., July, Oct.	11⅝	11 7/16
400,000	10	2/6	Eastern	14⅜ 14¾	14¾ 15	4 3 4	" "	14 13/16	14¾
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15½	15
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108 111	108 111	3 12 1	May and November	110¼	108¼
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅞ 15⅛	14⅞ 15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	14⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	106 109	106 109	3 13 5	February & August	108	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101 104	101 104	4 16 2	" "	102	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99 102	100 103	3 17 8	February & August	..	..
180,227	10	1/6	Globe Telegraph and Trust	9⅞ 10⅛	9⅞ 10⅛	5 6 2	Jan., Apr., July, Oct.	10⅛	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅝ 15⅛	14⅝ 15⅛	3 19 10	" "	15⅛	14⅝
150,000	10	5/0	Great Northern	18½ 19½	18½ 19½	4 8 4	Jan., April, and July	18½	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41 43	41 43	5 16 3	May and November	42⅜	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	7⅛ 8	7⅛ 8	5 3 2	April and October	..	..
3,381	£100 Cert.	6%	Submarine Cables Trust 6% .. x Oct. Coupon, 1891	115 120	115 120	5 0 0	" "	..	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	4 5	3½ 4½	.. ..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102 106	102 106	7 10 11	June and December	..	..
88,321	10	1/0	West India and Panama	1⅝ 1⅞	1⅝ 1⅞	.. ..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9⅝ 10⅛	10 10⅛	5 14 3	May and November	10⅛	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8½ 9½	8½ 9½	6 6 4	" "	..	..
67,007	15	6/0	Western and Brazilian	10¼ 10½	10 10⅛	7 2 10	" "	10⅛	10 1/16
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6½ 6¾	6½ 6¾	5 2 4	" "	6¾	6⅝
30,364	7½	7/6	Do. 5 per Cent. Deferred	4 4⅛	4 4⅛	.. ..	" "	4 3/16	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102 105	103 106	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102 105	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	97 100	97 100	6 0 0	March & September	..	..
			TELEPHONES.						
324,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜ ½	⅜ ½	8 7 7	May and November	..	..
x20,000	£1	4·76d.	Oriental (11s. paid)	⅜ ½	⅜ ½	6 3 11	Yearly	..	..
438,984	5	2/6	National	4½ 4¾	4½ 4¾	6 13 4	June and December	4¾	4⅝
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13½	12½ 13½	4 8 11	" "	13 5/16	13 1/16
15,000	10	6%	Do 6% Cumulative 2nd Pref.	11½ 12½	11½ 12½	4 16 0	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	106 107	105 107	4 4 1	January and July	106⅜	106
58,000	5	1/0	United River Plate	2 3	2 3	.. ..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£8 paid)	7⅞ 8¼	7½ 8	..	—	..	..
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	—	..	..
8,332	£5	..	House to House Electric	4½ 5	4½ 5	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5⅝ 6	5⅝ 6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5⅝ 6	5⅝ 6	..	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 paid)	2⅝ 3	2⅝ 2¾	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	4⅞ 5	4⅞ 5	..	March	..	..
111,000	5	..	London Electric Supply	⅞ 1⅛	⅞ 1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8½ 9	8½ 9	..	..	8 1/4	8⅝
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½ 5⅛	4½ 5⅛	—	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8½ 8¾	8 8¼	—	..	8½	8 5/16
7,900	£5	7%	Do. 7% Preference	7½ 7¾	7½ 7¾	..	..	..	..
42,853	5	..	Westminster Electric Supply (fully paid)	6½ 6¾	6½ 6¾	..	..	6⅝	6 1/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/0	Brush Electrical Engineering	3½ 3⅝	3½ 3⅝	..	..	3 1/16	3 1/16
69,996	2	6%	Do. 6 per Cent. Preference	2 2¼	2⅛ 2⅜	5 1 1	..	2 1/16	2⅛
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½ 6	5½ 6	5 16 8	January and July	5¾	..
17,130	5	17%	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	6 6½	6 6½	..	—	6 1/16	6 1/16
70,000	2	10/0	Elmore's Patent Copper Depositing	3 3½	2¾ 3⅛	—	—	3⅛	3
20,000	5	..	Fowler-Waring Cables (fully paid)	2 3	2 3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works .. x New	19½ 20½	19½ 20½	4 17 7	February & August	20½	19½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 106	104 107	4 4 1	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	4 5	4 5	.. ..	..	5	4¾
11,334	£10	8/0	Do. Preference	8 9	8 9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅜ ½	⅜ ½	.. ..	..	..	..
78,919	5	5/7½	Swan United (£3. 10s. paid)	4 4½	4 4½	8 11 10	May and November	4⅜	4 3/16
36,250	12	36/0	Telegraph Construction and Maintenance xd	43 45	43 45	5 6 8	March and July	44¼	43
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½ 1	½ 1	6 0 0	..	..	—
—	£5	8%	Do. Preference (fully paid)	2¼ 2¾	2½ 2¾	11 0 0	—	..	..
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	—	—	..	..
50,000	£10	—	City and South London Railway	3⅛ 3½	2½ 3⅛	—	—	3½	—

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NOTES.

The candour and frankness of Mr. Graff Baker's remarks at the discussion on Mr. Reckenzaun's Paper were thoroughly appreciated, and we hope that his statements will appear in full in the *Journal* of the Institution of Electrical Engineers. He had declined to give the figures of the Leeds line to the author of the Paper, since they needed certain preface and qualifications, and some men having given these explanations would have withheld the statistics. It is easy to understand that a 200 H.P. engine running at 75 H.P., cannot be expected to work economically. It is clear that American wheels may not be suitable for English rails. It is less easy to understand the difficulty of getting men to look after motors; and we cannot understand why so many details, which have been worked out with so much care by the Thomson-Houston Company, are found to give very inferior results when put to work in this country. We say that we cannot understand it, but we are not surprised at it. Three weeks ago we drew attention to the wide and still increasing divergence between American and English engineering.

There can be little doubt that accumulator traction must cost more than the overhead system in actual running expenses, exclusive of cost of plant. The North Metropolitan Tramway Company offered 4½d. per car mile for the electrical working of their line; and the contracting company, while realising that the number of cars was too small to make this pay, accepted the figure as a reasonable one, and attained a very fair degree of success. But Mr. Graff Baker, with the very latest equipment fresh from the land of electric railways, spends 6·63d. per car mile. This result is very interesting. We have been taunted by our American friends for our backwardness in electric traction, and it was supposed that the Leeds line was going to show us how to do it. We shall wait with interest the developments and improvements which are sure to be made, and the success which will in every probability attend Mr. Graff Baker's efforts. But if it is a matter of starting at 6½d. per car mile, and then developing and improving, why, we could do that without American assistance!

It is unmistakable that the Thomson-Houston system is all cut and dried so far as its use in America is concerned, and it is equally clear that the conditions of traction in England have been completely misunderstood by the engineers of that company. No sooner was the City and South London Railway open than the New York papers were full of schemes for a similar and practically identical line for that city. The case of the Leeds tramway may, perhaps, be a proof of the contention which we have so often put forward, that little or no useful comparisons can be made between English and American electrical engineering practice. We must gang our ain gait.

The debate in the House of Commons on Tuesday evening, which resulted in the rejection of Dr. Cameron's motion for the purchase of the telephones by the Government by 58 votes, was maintained at a high level of accuracy and interest by no means usual when a question involving technical knowledge is discussed by the Legislature. Dr. Cameron stated his views in a few well-considered words, and Mr. Quilter did not fail to make the utmost of the case for the National Telephone Company. Sir James Fergusson, while unable to accede to the motion, had a friendly word to say for everyone concerned, and especially for the telephone companies themselves.

The Chancellor of the Exchequer was of opinion that the Civil Service might well be congratulated on the fact that the House was so very ready to trust a vast and novel business to the management of the best abused of all public departments, and one which already employed 100,000 men, an army which the Government hesitated to increase. In the result, the country was committed to the Government half-way house scheme, from which sanguine Post Office officials appear to anticipate a sort of telephonic millennium, notwithstanding that almost every speaker was in favour of State control, and prophesied that in the end the Government would have to take another and a bolder step.

"A good deal of my life," said Mr. Forbes at the meeting of the shareholders of the London Electric Supply Corporation on Friday last, "has been passed in trying to make the best of a bad business, and it seems to me that that is what I have got to do to-day;" and without doubt the present situation of the Deptford scheme was bravely faced, and all the consolation that was possible was extracted from the succession of misfortunes that has beset it. Even after having to announce that a £50,000 five per cent. loan was to be raised

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by mortgaging the entire property of the Company, the chairman's armoury of philosophic dicta was not exhausted. A despairing shareholder was told that misfortunes were only to be redeemed by knowledge, and by courage; the Company could only be redeemed by people with sound information, not by mere talk; the Directors believed "in sticking to the thing;" some said he (the Chairman) was too sanguine, but the world was not carried on by "wet blankets," and his sanguineness was founded on his knowledge of difficulties overcome in other things. It is evident that the round peg is in the round hole this time.

It has been suggested by one of the learned counsel in the Lane Fox case that after the admirably clear and complete judgment which has been delivered, we ought to withdraw our remarks about Mr. Justice A. L. Smith's knowledge of electrical science. But does not the perfect lucidity and accuracy of this judgment redound greatly to the credit of the members of the Bar (to say nothing of the witnesses) who have succeeded in fifteen days in imparting a sound and sufficient knowledge of electricity, a clear notion of the charging and discharging, the practical use of secondary batteries, and a very clear grasp of the working of a supply system? What professor could do as much for a class? What crammer has done so much for a student? Those who are paid by results may well long for such a receptive and patient pupil.

When a committee of experts was nominated in connection with the Crystal Palace Exhibition, we remarked that there was a splendid opportunity for doing something, but we could not say what. A good suggestion or two appeared to be urgently wanted. Four months have passed, and not only have no tests been made, but no suggestions even have been heard of. All the meters in the Exhibition might have been coupled up in series on a bank of lamps, or a resistance, or a suite of furnished rooms. Even if the committee of experts did not decide as to which of the records was the most accurate, the readings might have been published, and the makers left to fight it out amongst themselves. The plebiscite system might be introduced, and a gold medal awarded for the meter which came nearest to the average of the whole. The voltmeters, ammeters, and other instruments might be judged in the same way. The jury would be saved a great deal of trouble, and the farce would not be much greater than it promises to be at present.

Kilkenny.—The Town Council have decided to borrow £12,000 for the purpose of establishing electric lighting works.

Gearless Motors.—The Short Electric Railway Company, of Cleveland, has secured from the Minneapolis Street Railway Company an order for 120 of their gearless motors.

The Government and the Telephones in Holland.—The Haarlem Chamber of Commerce has petitioned the Dutch Government to purchase the telephones, on the ground that the present service is both inefficient and expensive.

Physical Society.—Owing to the pressure on our space this week we have been compelled to hold over the discussion on Mr. R. W. Paul's Physical Society Paper on "Some Electrical Instruments," which will be found in the present issue.

Electric Traction in the Malay Peninsula.—It is proposed to build a light passenger electric railway from Singapore to Kranjie, connecting therewith a steam launch running to Johore. A concession has been granted, and the line commenced.

The General Electric Power and Traction Company.—We regret to learn that the works of this Company have been closed by order of the Board. We understand that the business of the Company will be carried on by the Electric Construction Corporation.

Gutta-Percha Cultivation.—M. Serullas, who received a subsidy from the Société d'Encouragement to assist him in his researches on the cultivation of gutta-percha in the Malay Peninsula, has written to the president of that society announcing successful results.

Sir John Pender, K.C.M.G.—During Sir John Pender's recent visit to Constantinople the Sultan conferred upon him the gold and silver medals of the Order of Imtiaz. This distinction is usually reserved for such of his Ministers as His Majesty honours with his personal friendship.

Nottingham.—Owing to the fact that many manufacturers and merchants have either provided themselves with installations or have intimated their intention of doing so, the Electric Lighting Committee of the Town Council have decided to take active measures for supplying the town.

Lightning.—Captain Calvert, of the Allan Line steamer "Prussian," on arriving at Greenock from Boston, reported that on the evening of March 6th a flash of lightning struck the mizenmast, stripping away about 12 feet of the timber, and setting fire to some hay which was below.

Taunton.—At a special meeting of the Town Council last week it was decided to employ an expert to prepare a report upon the suitability of the present buildings and plant for the lighting of the town by electricity, and that another special meeting of the Council should be held on Thursday, April 21st.

Electrical Bills in Parliament.—At a meeting of the Committee of Selection the following members were appointed to serve upon the Joint Committee of the Lords and Commons upon Electric and Cable Railway Bills:—Messrs. Stansfeld, Whitmore, J. S. Gathorne-Hardy, T. H. Bolton, and Story-Maskelyne.

University College, Liverpool.—Prof. Lodge has, with the approval of the Senate, appointed to the Demonstratorship in Electrotechnics Mr. Francis Gibson Baily, B.A., Assoc.I.E.E., late scholar of St. John's College, Cambridge. Mr. Baily took first-class honours in the Natural Science Tripos, and is now in the employ of Messrs. Siemens Bros. and Co.

Electrical Standardizing, Testing, and Training Institution.—The annual dinner of the students of this Institution was held on Wednesday evening at St. James's Hall. Lord Castletown of Upper Ossory took the chair, and among those present were Lord Russell, Prof. Robinson, Major Waller, Mr. Robert Hammond, Mr. Harrison, and Dr. Fleming.

Royal Society.—The following Papers were down for reading yesterday before the Royal Society:—"An Improved Apparatus for ascertaining the Sensitiveness of Safety Lamps when used for Gas-Testing" (and two other Papers), by Prof. F. Clowes; "Aberration Problems," a Discussion concerning the Motion of the Ether near the Earth, by Prof. Lodge, F.R.S.

Asbestos Porcelain.—On page 189 of our issue of December 25, 1891, we gave some particulars of a kind of porcelain made from pure powdered asbestos by a M. Garros. The conductivity of this material, when employed as the porous pot of a primary battery, has been tested at the Laboratoire Centrale d'Electricité, and found to be 2·75 greater than that of the porous pots usually employed.

Report on the Thunderstorms of 1888 and 1889.—A report, by Mr. William Marriott, on the systematic investigation of thunderstorms, has been issued in the Journal of the Royal Meteorological Society. No very definite conclusions have been arrived at; but attempts have been made to ascertain the paths and rate of travel of thunderstorms, and their relation to the distribution of atmospheric pressure.

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Liverpool.—It will be remembered that a short time since fires occurred in some of the junction boxes in Liverpool. Major Cardew was recently sent down by the Board of Trade to make an examination, and a copy of his report has been submitted to the Watch Committee of the Corporation, and the city engineer has been instructed to make an inspection of the street boxes, and present a further report to the Committee.

O.S.A. Smoking Concert.—One of the best concerts ever given by this society took place on Friday last at Masons' Hall Tavern. Messrs. Adams, Deane, Dundas, Fitzgerald, and Russell were the vocalists. Mr. Melrose was excellent in the humorous sorgs, Mr. Crawley gave some very original recitations, and Mr. Slocombe was the violinist. Messrs. Lamb and Norman acted as accompanists. The next smoking concert will be the last this season.

Erding.—The town of Erding in Upper Bavaria has decided to adopt electricity for both public and private lighting. Power will be derived from a waterfall, a little over two miles distant. Messrs. Siemens and Halske, of Berlin, will carry out the work on the "drehstrom" system. The primary current will be conveyed at 1,000 volts, being transformed down to 115 volts. Applications have been received for connecting a large number of motors. The firm has undertaken to complete the work within six months.

Electricity in Ceylon.—Progress is being made with the work of utilising water-power to supply electrical power to Mariawattee factory, says the *Indian Engineer*. A water-course is now being constructed, and buildings are being erected for the turbines and dynamos. It is proposed to obtain 200 H.P., 50 H.P. for each of the two factories belonging to the Company, and 100 H.P. available for others in the neighbourhood who may wish to hire power from them. It is estimated that the cost of the installation will be £4,000.

Gas and Electricity in Paris.—In a recent report to the Conseil Municipal of Paris M. Paul Brosse gives some statistics with regard to the relative positions of gas and electricity in that city. The consumption of gas continues to grow, although the rate of increase is somewhat less than it was. The Paris central stations have at the present moment plant capable of developing 17,500 H.P.; when complete this figure will become 32,000. During 1891 the gas consumed in Paris amounted to 10⅗ million thousand cubic feet. Out of 85,000 houses only 20,000 are fitted with gas.

The Benevolent Fund of the Institution of Civil Engineers.—This fund has entered upon its twenty-eighth year. The invested capital is £[illegible]8,137. 0s. 2d., and the dividends realised on this account in 1891 amounted to £1,359. 18s. 11d. The annual subscriptions, derived from 768 subscribers, yielded £1,548. 18s. 6d., or not quite one moiety of the income. The actual receipts during the year were £3,413. 9s. 11d. The payments included grants aggregating £3,245. 5s., in 55 cases. The auditors call attention to the small cost of administration, which is only 3 per cent. of the receipts.

Telephone and Electric Light Wires in Germany.—The induction between electric light and telephone circuits has been the subject of considerable investigation and discussion in Germany, due to the intention of the German Postal Telegraph authorities to push a Bill through the Reichstag, giving them the power to do pretty well what they like with overhead or underground conductors carrying "energetic currents." There is great opposition to the Bill, its opponents alleging that the telephone wires can be properly protected against induction without the exercise of any such powers as are asked for.

Coast Communication.—On Tuesday last Sir E. Birkbeck asked the First Lord of the Treasury whether, in view of the great importance of rendering every facility for the better preservation of life and property round the coast of the United Kingdom, he would be good enough to grant an early opportunity for a debate on the question of coast communication. Mr. Balfour said it was impossible for the Government to make an exception in favour of a particular resolution, although they were in hearty sympathy with the objects in view, and he hoped that something material would be done towards carrying them out.

The London and Paris Telephone Line.—Experiments have been recently made by the technical staff of the Post Office on various forms of transmitters in connection with long-distance telephony. The two circuits were coupled together at Paris, and speech was transmitted over about 620 miles of line, from one room in the General Post Office to another. Conversation has been carried on with complete success between London and Marseilles on several occasions; but it is not intended to open this route to the public at present. The Post Office pattern of Gower Bell, and a modification of the Hunnings transmitter are found to be as good as any other on this line.

Cable Interruptions and Repairs:

	Date of interruption. 1891.		Date of repair. 1892.
Brest-St. Pierre Cable (Anglo-American)	Nov. 19	.. ..	*
	1892.		
Perim-A-sab Cable	Jan. 5	.....	March 26
Para-Maranham Cable	„ 18	.....	March 19
Zanzibar-Mombassa Cable	Jan. 25	.....	Feb. 23
Brest-St.-Pierre Cable (Cie. Française)	Feb. 13	.....	Feb. 24
Saigon-Singapore Cable	„ 18	.....	Feb. 23
Hong Kong-Macao Cable	Mar. 7	.....	March 17

* Not yet re-established.

The School of Electrical Engineering and Submarine Telegraphy.—We are informed by Mr. L. Drugman, Manager of the above school, that, as the result of the recent examinations held by Mr. Gisbert Kapp, the following gentlemen have obtained the certificate:—Messrs. P. W. Burman, W. J. Davy, W. Dickinson, L. Goichot, C. H. Gray, L. Leskovic, S. E. Linsell, and R. A. Smith. The examination consisted of a Paper in mechanical engineering, a Paper in electrical engineering, a *viva voce* and practical examination; also engineering design done during the term and average of two test examinations; 66 per cent. of the marks were necessary for the obtaining of the certificate.

Underground Mains in Paris.—According to *l'Industrie Electrique*, the Compagnie Continentale Edison has had difficulties with its underground mains. The type of conduit originally adopted (see *The Electrician*, Vol. XXIII., p. 250) was very similar to that known to us as the Crompton system. But in Paris, as in London, want of space precluded its universal use. The Company, therefore, looked out for a system which, while occupying less space, should still allow of bare copper conductors being run everywhere. At this juncture Jacob Frères, of Pouilly-sur-Saône, suggested rectangular earthenware troughs. These were used in places, and at first gave good results. After a time, however, the insulation fell, owing to infiltration and chemical action, and the Edison Company has now reverted to its first plan.

The Thomson-Houston Company at Work in Germany.—At Berlin, says our correspondent, the "Elektricitäts-Gesellschaft Union," that is the Thomson-Houston Company, is busy preparing for an important move. There is a rumour to the effect that this Company will swallow up several of the smaller fry, who are at present doing a good business, though without the necessary capital behind them. The German capitalist "sits upon his money," and the civic authorities also sit upon their's, and both of them are waiting for the production of electricity to become cheaper and for the experts to agree upon one system as being the best. At present if three of these learned gentlemen are consulted they give three different answers, and as each of these answers takes a whole year to be fully digested the whole matter is relegated into the distant future.

The London County Council Subways Bill.—The Select Committee of the House of Commons, presided over by Mr. H. Gladstone, resumed their consideration of this Bill during the week. Sir Frederick Bramwell, who was the first witness, said there was an essential difference between a gas or water pipe and an electric main. He pointed out that an electric main was a comparatively small object, and that the capacity of a system of electric mains could be added to without breaking up the streets, which was not the case with gas or water

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pipes. If it were rendered obligatory to remove the mains into the subways the public would be exposed to a great deal of annoyance, and the companies would be put to a large expense. Dr. Hopkinson, Prof. Kennedy, Major-General Webber, Mr. R. E. Crompton, and Mr. F. Bailey also gave evidence against the Bill.—On Wednesday the Committee decided not to exempt the electric lighting companies from the operation of the Bill, but decided that any cost which they might be put to in complying with the provisions of the Bill was to be borne by the County Council.

The Chicago Exhibition.—The Electrical Committee appointed by the Royal Commission for the Chicago Exhibition met on Monday, the 28th ult. The Chairman (Mr. W. H. Preece) reported that he had received information from Chicago that one of the engineers of the electrical staff of the Exhibition was about to be sent over to this country to confer with the Committee on the question of arranging for some portion of the Exhibition to be lighted by European firms. It was agreed to postpone the consideration of this question pending the arrival of the gentleman in question. The Chairman also informed the Committee that there was every prospect of the electrical industries of this country being adequately represented. Several of the newest forms of engines and dynamos for electrical installations would be shown; and it was probable also that arrangements would be made for showing a series of rooms, furnished in the English style, and fitted with the most recent applications of the electric light. The Attorney-General stated in the House of Commons a few days ago that the Royal Commission had asked for a substantial increase of the Government grant.

Relation of Voltaic E.M.F. to Molecular Velocity.—In a recent research published in Vol. VIII., p. 63, of the *Proc.* Birm. Phil. Soc., 1892, Dr. Gore shows by means of an extensive series of 64 tables of measurements of mean volta E.M.F., that the dilution of the liquid of a voltaic cell by means of water or alcohol, the liquefaction of either the positive or negative metal of the cell by means of mercury, the dilution of either of these amalgams by means of mercury, the dilution of one solid metal by means of another in an alloy, is universally attended by an increase of mean E.M.F. of the diluted and diluting substances, and consequently also of the actual E.M.F. of the diluted one, provided that in all cases no chemical union or other chemical change occurs in the mixture. The manifest explanation of this extensive general result is, that by the act of solution or dilution, the molecules of the active substance are separated farther apart, and consequently acquire increased velocity of motion. In proportion, however, as chemical union occurs, the gain of E.M.F. diminishes, and is converted into a loss, and the loss is larger in proportion as the chemical union is stronger. The method enables chemical compounds in alloys, amalgams, and electrolytes to be distinguished from mere mechanical mixtures.

Engines for the Electric Light.—A correspondence has been recently running in the columns of the *Engineer* on the subject of engines for electric lighting purposes. The following is an extract from "A Volt's" latest contribution to the controversy:—

"I am quite content to concede that the Willans engine will run for 10 years, or even 20 years, if that will satisfy 'I. I. I.;' but even he will admit, I suppose, that the Willans engine is not immortal; and as he evidently knows all about it, is it too much to ask him to tell your readers in what way it generally fails when it does fail? If it does not go to pieces all at once, then it fails by degrees—a bit at a time. I want to know which bit, in his experience, fails first, and has to be replaced. The simplest plan would be to say what is the maximum sum he has known to be paid for repairs of a Willans engine of fair size, say indicating 50 H.P. in any one year. This is information that will go home to the hearts of steam users. I know of an instance in which a slow-speed horizontal mill engine by a Belgian firm ran for 10 years without the outlay of one sixpence in repairs. The letting of the brasses together was done on Sundays by the engineer in charge. The piston was not drawn for ten years, and it was in fair condition and steam-tight at the end of that time. I myself indicated and reported some years ago on a Watt engine, made in 1819, which had worked twelve hours a day for 44 years, and had the original brasses in. This engine had cost next to nothing for repairs. I do not suppose that any high-speed engine will give such results as this. But I gather from 'I. I. I.'s' letter that something like it may be expected. But I do not want to know what may be expected. I want to know what has actually taken place. Surely your correspondent, or someone else who has used the Willans engine, can give some information. I am told many things good and bad of it. Let us have the facts. One thing, for example, that I have heard is, that dirty steam will ruin the piston valves, even going so far as to set them fast and lead to a breakdown. Has this ever happened? Would I be quite safe in putting a Willans engine to work with a water-tube boiler, which primes furiously if it is not cleaned out once a fortnight?"

The Influence of Polyphase Currents on Telegraphic and Telephonic Circuits.—During the working of the Lauffen-Frankfort transmission plant the German postal telegraph authorities carried out a series of experiments with a view of testing the effect upon their lines of circuits carrying polyphase currents. On the first four single-wire telephone circuits selected, which varied in length from 1 mile to 3½ miles, and which were at an average distance of 10 metres from the disturbing circuit, a constant humming was heard, which in wet weather rendered all conversation impossible. Tests were next carried out on two private telephone lines. One of these started at a great distance from the polyphase current wires, and crossed them at a given spot. The other line ran alongside the Lauffen-Frankfort circuit at a distance of from 5 to 15 metres for a little over half a mile. Both lines were rendered useless. On the Heilbronn-Mosbach circuit, 18 miles long, telegraphic communication was exceedingly difficult. On several other telegraph circuits whenever 25,000 volts were applied to the Lauffen-Frankfort line, the armatures of the electro-magnets kept up a continual vibration. Experiments were also carried out on the Stuttgart-Heilbronn double-wire telephone circuits (7½ miles). With 10,000 to 15,000 volts on the Lauffen line a noise was heard which increased with the voltage applied until with 25,000 volts on all conversation was rendered inaudible. The general conclusions to be drawn from these experiments are as follows:—(i.) The influence of polyphase currents (increasing with the voltage) was felt on lines traversed by telegraphic and telephonic currents and placed at an average distance of 10 metres from the disturbing circuit, for stretches ranging from ½ to 18 miles. (ii.) Lines merely crossing the Lauffen-Frankfort wires were disturbed, as well as complete metallic circuits.

The National Telephone Company.—The London general staff of the National Telephone Company held their annual dinner in the Chapter-room of Anderton's Hotel, Fleet-street, E.C., on Friday last; the chair being occupied by Mr. Dane Sinclair, and the vice-chair by Mr. Thomas Fletcher. Amongst about 70 members of the staff present were Mr. Calder, Mr. Turner, Mr. Phillips, and other heads of departments. An excellent dinner was provided, after which the evening was devoted to music and speech-making. The latter function is usually somewhat depressing; but on this occasion the chief members of the Telephone Company's staff gave expression, in tones of unmistakable sincerity, and in forcible language, to their views upon the rights and wrongs of the "Telephone Question." After the usual loyal toasts, Mr. Fletcher proposed, in a brief speech, "The National Telephone Company, its President, Vice-President, and Directors;" and in replying to this toast the Chairman went sympathetically into the burning question of the opposition to the National Company—more especially the opposition of the Post Office. It was claimed by Mr. Sinclair that the difficulties which have been overcome, and which have to be overcome before the telephone can attain its perfect success, are known only to the men whose every day duty it is to face these difficulties. He then dwelt upon the personal popularity of the President and Vice-President of the Company, and upon their willingness to meet in every possible way the wishes of subscribers to the telephone, if only Parliament would aid them in so doing. Without such aid complete success was impossible. If the Post-Office decided to take over the telephones, this aid from Parliament would be not a whit less essential to that Department. The speaker also feelingly referred to the assistance rendered to the chief officials of the Company by the "most capable and complete telephone staff in the world," and concluded by inviting those present—and especially the young men—to stand by the Company and manfully support them in their efforts to secure a perfect telephone service, in spite of the opposition of those who, now that success was within sight, wished to snatch the credit of this success from them. Mr. Sinclair was warmly applauded, a proof that he correctly gauged the feelings of his audience.

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NOTES ON SUBMARINE CABLE WORK.

BY H. D. WILKINSON.

(*Continued from page 517.*)

6. Buoying the Cable.—Some reference to the preparations made on board for buoying cable may be of interest. The buoy is first got ready, the flagstaff and flag put on, and the buoy slung on to a block and tackle secured to a convenient place in the rigging. In this position the buoy is outside the shrouds and resting on two wooden skids ready for lowering, the fall on the block being of sufficient length to lower the buoy into water. Fifteen fathoms of mooring chain are reeved through the eye at the bottom of the buoy and fastened at the top in one of the slip links, while a short length of bridle chain is attached to the other slip link on the buoy and shackled below to the mooring chain as shown in Fig. 22. The bridle-chain and slip links do not come into use till the ship is about to heave up the cable-end again, after having completed the repair on the other end; but their use may be briefly explained. When the ship is up to the buoy on the return journey, a boat is put off with hands to attach a line from the ship to the bridle chain. The line is connected to the drum of the picking-up gear on board, and after heaving up a little, the bridle chain is freed from the buoy. The strain of the cable is then taken by heaving up a little more, and the mooring-chain can then be disengaged from the buoy.

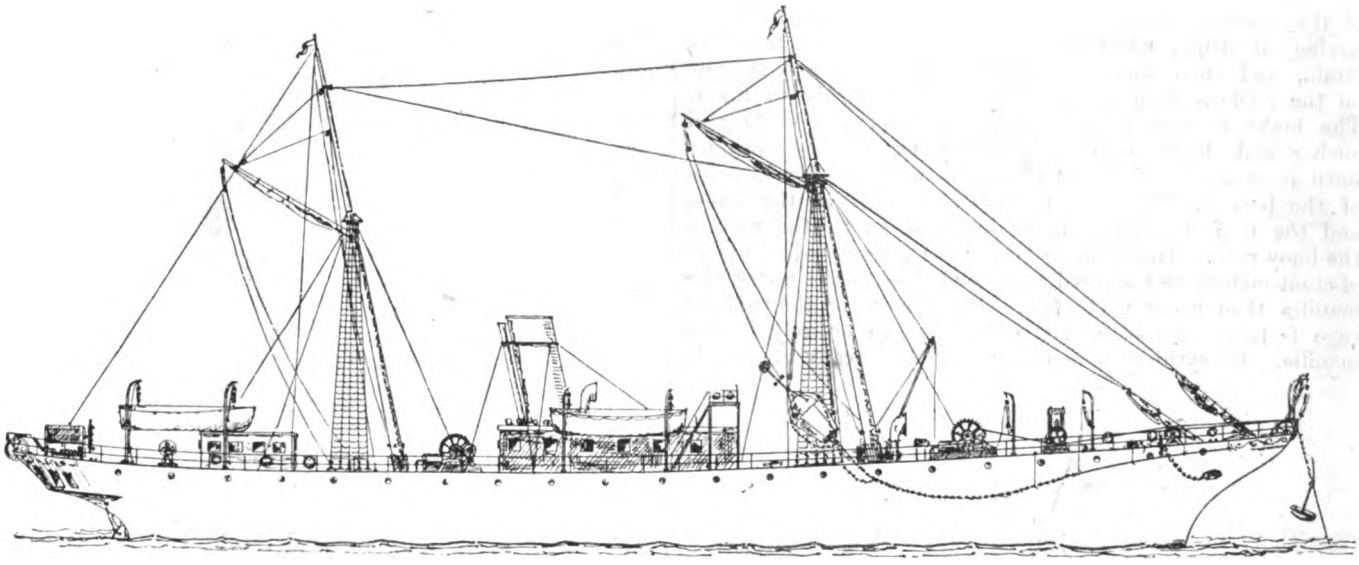

FIG. 21.—Cable Ship preparing to Buoy Cable.

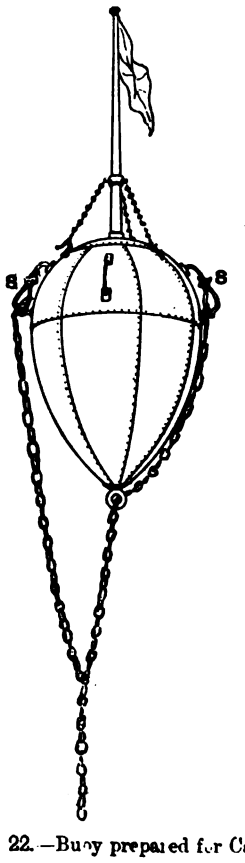

FIG. 22.—Buoy prepared for Cable.

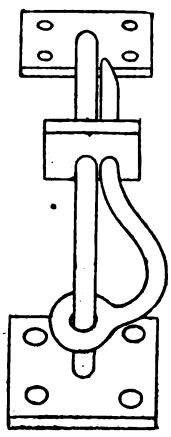

FIG. 23.—Snatch Link on Buoy.

The slip links (S S, Fig. 22) are for disengaging these chains easily, when freeing the buoy. One of these links is shown in detail in Fig. 23. The link is in two parts, one of which is a loop of iron rod fixed permanently on plates rivetted to the buoy, and the other a piece of bent rod tapered at one end and working on the lower part of the fixed loop. The diagram shows the link as fixed, and held together by a square washer holding the tapered end of the moveable loop against the fixed one. To open the link this washer is given a smart blow upwards, when the moveable part falls and disengages the chain.

Another way of attaching the bridle chain to the buoy without the use of a slip link is practised with buoys having rigid iron stays, supporting the flagstaff ring, instead of chains, as shown in the engraving. Such buoys are only provided with one slip-link, which is used for the mooring chain, but have in addition a chain permanently fastened round the body of the buoy, to which the bridle chain is attached a few feet from its end by a seizing of spun yarn. The few feet of slack on the bridle chain are then made fast to one of the rigid flagstaff stays by taking two round turns on the stay and then two seizings of spun yarn. When the ship is up to the buoy on the return journey a boat with hands is put off to the buoy, one of whom cuts adrift the seizings to the stay, and unwinds the round turns. He then has the few feet of slack chain over the bow of his boat, and shackles the end of the same on to the drum line of wire rope thrown from the ship. While he is doing this there is no downward pull on the chain, as it is still held by the seizing on the buoy chain. As soon as shackled the ship heaves in a little on the drum line to take up the slack, and on the word of command from the ship the man in the boat cuts the last seizing adrift. The ship now has a clear way to take the strain of the cable, and after heaving up a little more to take the strain off the mooring chain on the buoy, the man rows round to the slip link on the other side of the buoy, and on the word of command from the ship to "knock up," gives the washer on the slip link a blow upwards, opening the link, and allowing the mooring chain to slip off, leaving the buoy quite free.

But to return now to our preparations for buoying. On the end of the mooring chain about 20 fathoms of rope are attached, and the chain and rope so attached to the buoy are

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led along outside the ship to the bows and held a few feet above the water by pieces of small line tied to the gunwale, a few feet apart. The appearance of this is sketched in Fig. 21, which represents a cable ship preparing to buoy cable. Meanwhile the end of the cable at the bows is prepared for mooring. The mushroom anchor is attached directly to a length of mooring chain, while a few fathoms away from the mushroom another chain is attached to the mooring chain, the other end of which is made fast to the cable. The chain is put on the cable with back hitches and stoppered on with spun yarn. The free end of the mooring chain is shackled to a rope wound over the paying-out drum, which is heaved in a little to take the strain, and then heavily braked. The stopper first put on the cable is then cut adrift, and all is ready to lower. The brake is now released gradually, and the cable and anchor sink below water, while the paying-out continues until it is known that the anchor is within a few fathoms of the bottom. The rope is then stoppered at the bows, and the nearest thimble in it shackled on to the end of the buoy rope. The bight so formed is then secured to a piece of stout manilla and lowered overboard close to the water, the manilla then being made fast. The stopper on the paid-out rope is then released, and the strain taken entirely by the manilla. Everything is now overboard and ready to launch,

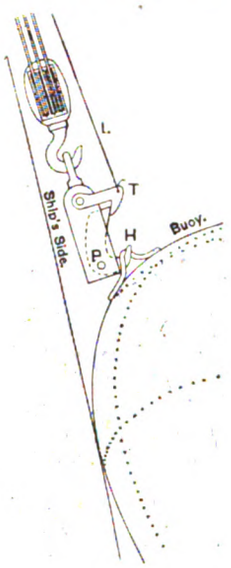

Fig. 24.

and it only remains to lower the buoy into the water by the tackle. The buoy is slung to the tackle by a detaching hook, H (Fig. 24). This is set into a ring on the buoy as shown, and is pivotted at P, and kept in an upright position by the trigger, T. To free the buoy, the line L is pulled on deck, lifting the trigger and freeing the hook, which, pulled down by the weight of the buoy, turns over on the pivot and allows the buoy to fall into the water. This done, the manilla is cut adrift, and immediately the small rope supports holding up chain and rope to ship's side are torn away by the strain, and the buoy, with the cable anchored below, floats free of the ship.

(To be continued.)

SOME ELECTRICAL INSTRUMENTS.*

BY ROBT. W. PAUL.

The increasing number of cases in which accurate electrical measurements have to be made, render it more than ever necessary to devote attention to the design of instruments, with the object of making their use more convenient and expeditious as well as accurate.

Consider, for example, the form in which the standard ohm is usually constructed, the coil having two or more layers of many turns each; in using such a coil for accurate measurements there is considerable delay in waiting for the temperature of the coil and water-bath to become uniform and equal, and even then an uncertainty remains as to whether the turns near the top of the coil are at the same temperature as those at the bottom.

After heating the bath, even with stirring, the water at the top may be at a higher temperature than that at the bottom. The

Fig. 1.

surface from which heat generated in the coil may be got rid of by conduction and convection, is comparatively small.

Prof. Fleming, in a Paper read before this Society in November, 1888, pointed out these disadvantages, and described a coil in the form of a ring of square section, which to a great extent obviates them. But even this coil has some length, and it has seemed possible to go still further in this direction, and at the same time to simplify the construction.

In the ohm coil shown in Fig. 1 the wire is wound in a flat spiral, being first doubled on itself in the usual way to avoid self-induction; the spiral is enclosed between two thin brass plates, forming part of a very thin, flat, water-tight box, and the electrodes pass up the central tube. The wire is thus at one level in the liquid, and has, therefore, a better opportunity of acquiring a uniform temperature, which may be accurately ascertained by a delicate thermometer passing down the centre, with the bulb at the level of the spiral; a second thermometer, in the water, at the same level, serves to check the uniformity of temperature. In order that the width of the coil may not prevent

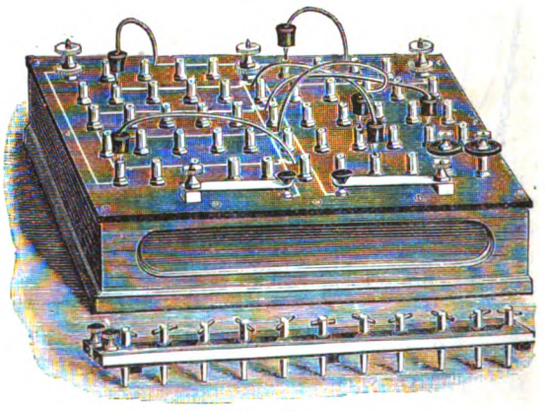

Fig. 2.

any slight convection currents from having free play, the screws which hold the plates together have large holes through them. Following Prof. Fleming's suggestion, the upper ebonite insulator is formed into a cup to contain paraffin oil to prevent surface leakage through deposited moisture.

The resistance box shown in Fig. 2 is the outcome of some attempts to improve the ordinary form. The coils are arranged in sets of ten each, and their ends are connected to sockets

* Paper read before the Physical Society, March 25, 1892.

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fixed in rows on an ebonite board. Successive coils are put in circuit by placing a plug, attached to a flexible cord, in the required socket. Thus the resistance may be increased from 1 to 11,110 ohms by steps of one ohm if necessary. The advantages which accrue from this arrangement are found to be as follows:—The danger of surface leakage across the ebonite from block to block in the ordinary form, where the narrow gap between them is not easily kept clean, is obviated by the large open space between the sockets. The contact resistance in circuit is constant and easily measured; it is reduced to a minimum by each plug fitting solidly, the contact being over the whole of its circumference instead of on about one-third of it, as in the ordinary form. The hole between the blocks of an ordinary resistance box alters its form with temperature, or any warping of the ebonite board, but the contact resistance at these sockets is not affected thereby. A rise in temperature of 20° C. will make the longer diameter of an ordinary resistance box plug-hole one-half per cent. greater than the shorter, owing to the difference between the coefficients of expansion of ebonite* and of brass. The flexible cords each consist of between two and three hundred strands of fine copper wire, and are not found to be affected by use.

In using the set of coils as a Wheatstone bridge, or as an ordinary resistance box, the rapidity and ease of adjustment of the well-known "dial" form are preserved, while the instrument is more compact and portable; the plugs, being attached to the instrument, are not liable to be mislaid.

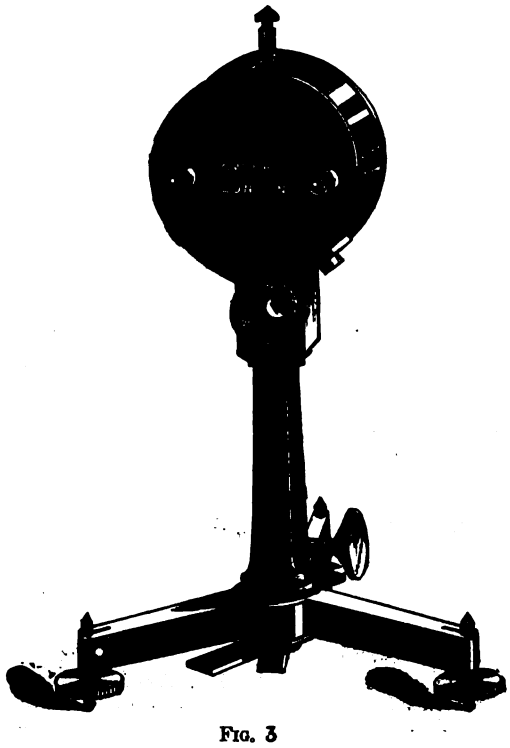


Fig. 3

But the arrangement of the instrument renders it available for several other uses. By means of the special contact bar shown in the illustration, from 2 to 10 coils in each row may be placed in parallel, thus making the instrument available as a conductivity box of large range for measuring low resistances. For the measurement of currents by the voltmeter method, 10 one-ohm, or 10 one-tenth ohm coils may be placed in parallel to give accurate resistances of 0·1 and of 0·01 ohm good carrying capacity. Several derived circuits may be made in the one resistance box.

By means of the contact bar, large ratios between two resistances of great importance in the construction of high resistances may be accurately obtained. To do this the method described by F. Kohlrausch† is employed; for example, one set of ten coils being put in parallel so as to nearly equal the other set of ten coils in series. The small difference (error) between the two is ascertained by Foster's method. Then each of nine of the higher resistances being checked against the first of its series, all the data for finding the exact proportion between the first coil of the one set and the other set of ten in parallel are ascertained.

The set of coils may be used as a potentiometer by connecting the battery to its terminals and using a pair of travelling plugs, between which any resistance from 0 to 10,000 ohms may be included.

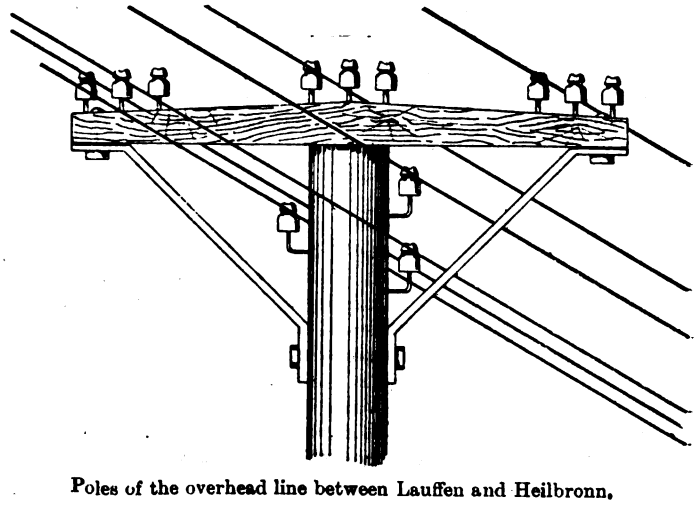
The reflecting galvanometer, illustrated in Fig. 3, has coils enclosed in ebonite boxes turned out to fit them. They are wound in accordance to Sir W. Thomson's law for the greatest magnetic effect at the centre, each being provided with terminals, they can be joined up as desired, and a pair of high or of low resistance coils may be used in the same instrument. When used as an astatic galvanometer, one of the needles is placed at the back of the mirror which moves in the thick metal box below the coils, and the plug which carries the window in front may then be pushed in to aid in damping the vibrations of the needle by air-friction. The needle may be easily removed, the suspending fibre passing through a slot in the case. It can be replaced by a ballistic needle, in which case the mirror carries no magnets, and the air-damping can be minimised by sliding out the plug. This part of the instrument is mounted on an ebonite pillar to give good earth-insulation, and the directing magnets are placed at the base, so that they may be adjusted without setting the instrument in vibration.

*As given by Mayer, *Amer. Jour. Science*, xli., p. 54, 1891.
†*Annalen der Physik und Chemie*, xxvi., 1887.

THE LAUFFEN-HEILBRONN TRANSMISSION PLANT.

[Communicated.]

The "drehstrom" installation at Heilbronn is working, though not working equally well in all its parts. The total water-power of the Portland cement works at Lauffen some 6 miles off,



Poles of the overhead line between Lauffen and Heilbronn.

is 1,500 H.P., of which 600 H.P. are used by the works themselves, the rest remaining available for electrical purposes. There are five 300 H.P. turbines, running at 35 revolutions. One of these drives an Oerlikon dynamo, giving 50 volts and 4,000 amperes at 150 revolutions, with a frequency of 40 ∿. The 50 volts are transformed up to 5,000 volts for transmission. It is a remarkable fact that the oil insulation has been taken away from all the high-pressure converters, practical experience having shown several inconveniences, of which, however, Herr O. von Miller does not like to give detailed accounts. At least, Herr Meissner, his engineer, who gave these details at a meeting of the Elektrotechnische Verein at Frankfort, did not answer any of the questions, asking for the causes of the failure of the oil insulation. Oil is, however, still retained within the line insulators. The line (*see* figure) consists of three bare copper wires ¼in. in diameter, which had to be placed 5ft. above the trees, and 12ft. above the houses, which entailed the use of poles 36ft. to 48ft. high. Each of these poles carries

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mine oil insulators, thus providing for a future increase of the plant. At the lower part of the poles there are small wires for measuring purposes and telephonic communication between the town and the generating station, the former only being able to call the latter by disconnecting the voltmeter leads and thus making the voltmeters at the station swing back to zero. The line terminates before it reaches Heilbronn at a small cottage containing the step-down transformers which convert the 5,000 volts into 1,500. From this cottage triple concentric cables lead to the places where the tertiary transformers are banked, each sub station containing at present only one 40 kilowatt transformer and space for a second one. These tertiary transformers step down from 1,500 volts to 100.

All the house-wiring is done upon the three-wire system, with three-pole fuses. Installations under 10 lamps are wired upon the two-wire system only; but three wires enter the house, and from the main fuse that part is taken which experiment shows to be the best. The incandescent lamps are now burning well, though they are sometimes subjected to fluctuations of pressure of from 3 to 4 volts. Before the equal distribution of the lamps upon the two sides of the three-wire network had been thoroughly carried out these fluctuations amounted to 7 volts. The calculated losses in the leads are 14½ per cent. in all, of which 10 per cent. takes place in the overhead wires, and 3 per cent. in the 1,500 volt cables, leaving 1½ per cent. to be debited to the distributing mains, a loss which, in face of the above-mentioned fluctuations, seems a trifle under-estimated. The line has withstood a heavy snow. Of "drehstrom" motors there are three at work, two of 2 H.P. each, and one of 6 H.P., the former without the latter with sliding rings. The 6 H.P. motor is said to take nearly 50 amperes for running without load, but not much more if running under full load. The meters used are of Dr. Aron's well-known type.

ELECTRIC LIGHTING BY WIND POWER.

The windmill which was erected by Messrs. Carwardine and Co. at their flour mills in the City-road, London, some two years ago, has for the last three weeks been connected to an electric lighting plant, which is now running successfully. The windmill was erected by Messrs. Alfred Williams and Co., of Great Eastern-street, and is of the American wheel or disc type. The lathes are self-adjusting, to suit the varying pressure of the wind, and the mechanical construction is very substantial. A framework of 10in. timber is carried on an upper floor to a considerable height above the roof. The power which has hitherto been used for milling and hoisting is now employed to drive an Elwell-Parker dynamo by means of a countershaft and belt. An automatic switch is connected to the dynamo, and cuts in when about 70 volts is reached, dropping out again at about 50 volts. A battery of 28 E.P.S. cells is used, and the dynamo charges them with a variable current which rises during a fair breeze to 30 amperes. On the overhanging end of the dynamo shaft a centrifugal governor, such as is used for train-lighting, is mounted. When a certain speed is exceeded a switch arm is pushed over and puts resistances into the shunt winding of the field-magnets. Two arc lamps and a number of glow lamps are run off the batteries, and the light is highly appreciated by the proprietors of the mills. The electric plant was put down by Messrs. Wenham and Co., of Upper Ogle-street, W.

A Paper was read by Prof. J. Blyth at the Royal Scottish Society of Arts in January last, on some experiments on the application of wind power to the driving of dynamos, and a very large mill erected by Mr. Brush at Cleveland was described in *The Electrician*, Vol. XXVI., p. 290. Very little practical advance has however been made in this direction. There are several difficulties to be met in making the apparatus perfectly automatic; and it appears that if wind power is to be seriously used for country houses, &c., it would be better to stop charging while the lights are being used. In any case, the first cost must be considerable, and while windmills are being replaced by steam-engines, even in Holland, where the use of wind power is best understood, it does not seem profitable to attempt to do more than 3 or 4 H.P. by this means.

Windmills have shown themselves to be better adapted for pumping than for any other work. A curious example has been described of a Californian windmill. It was desired to store up the power, but as water was very scarce, the wheel was arranged to hoist dry sand into a reservoir, and this was used to drive an overshot wheel when power was wanted. The Genevese system of hydraulic storage might, perhaps be successfully applied to windmills. A three-throw force-pump might be provided with a variable stroke or its equivalent, in connection with a governor. With light winds the back pressure would not pull up the mill, but it would continue to store, though slowly. Every stroke of the force-pump would deliver a definite quantity of water, whether the mill was running fast or slow, and no waste would occur, as when resistances, cut-out switches, and batteries are used. A single pipe only would be needed for both storage and delivery, and the lights could be run from a turbine-driven dynamo whether the windmill were pumping or no. The only drawback, but one which is so fatal in tide-mill schemes, is the first cost.

NORMAL AND HISSING ARCS.*

BY J. R. CRAVATH.

The electric arc has heretofore been investigated more from a purely electrical than from a broad physical standpoint. The relation of voltage, current, resistance, &c., in different arcs has received more attention than the action taking place in the arc itself. In other words, the arc has been dealt with through the agency of the voltmeter and ammeter, rather than "face to face." The electrical part of the work having, therefore, been pretty thoroughly done, this Paper will treat only of the action of the arc itself.

The normal silent carbon arc, Fig. 1, consists of a stream of carbon vapour appearing to arise from the boiling crater on the positive carbon and touching the white hot point on the negative. This cone-shaped stream of vapour burns where it comes in contact with the surrounding air. The whole surface of the crater is in a steady

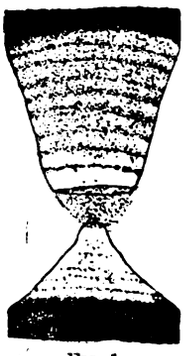

FIG. 1.
The Normal Silent Arc.

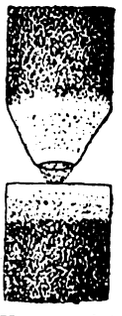

FIG. 2.—Upper pointed carbon positive. No hissing when positive carbon is moved horizontally.

boil and gives off vapour equally from all parts. However, under certain conditions, the arc will hiss and become unsteady.

The conditions which produce hissing are: first, air currents, carbon impurities, &c.; second, shortness of arc. The following simple tests were devised by the writer during his investigations to locate definitely the part of the arc which is responsible for the hissing. Owing to the fact that hissing is always accompanied by unsteadiness, it was reasoned that it might be due to the changing of position of the vapour stream on either the positive or the negative carbon tips, and that the sound was caused by either the heating or cooling of the hot carbon, or by condensation of vapour on the negative.

An ordinary arc lamp was so fixed that one of the carbons could be moved in a horizontal direction without changing the length of the arc. It was then fitted with carbons, as shown in Fig. 2, using an ordinary carbon (burned to the regular shape) for the positive, and one having a flat end for the negative. If now an arc be struck between these carbons any horizontal movement of one of them will simply change the spot on which the vapour strikes the negative without influencing the positive in any way. This movement was made when the arc was burning silently, and the arc continued

* From the *Electrical World*

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to burn silently during the movements, showing that the hissing was not due to condensation on the negative.

The carbons were then reversed, using a pointed one for the negative and a flat ended one for the positive, as seen in Fig. 3. In this case, of course, the positive crater will be obliged to change its position at every horizontal movement of the carbons. In this test every movement was accompanied with a hiss, showing that hissing is caused either by the sudden heating of the carbon to the boiling temperature of the crater, or by the sudden cooling of the boiling carbon formerly in the crater. The former theory seems most probable, for if the latter were true every arc lamp would hiss when the current is turned off; and this is not the case.

In the light of these experiments there is no difficulty in discovering the immediate cause of the hissing in short arcs. In looking at one (Fig. 4), we see that, instead of a stream of vapour coming

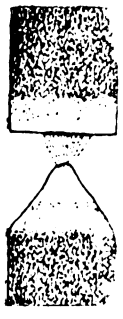


FIG. 3.—Upper flat carbon positive. Hissing caused by moving positive carbon about.

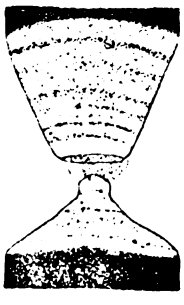
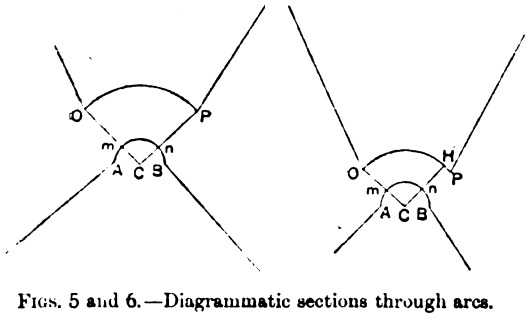


FIG. 4. The Hissing Arc.

from the entire surface of the crater, there is a stream coming from only a part of the surface, and that the rest of the surface is at a temperature below boiling. The immediate cause of the hissing must be the fact that the boiling surface is constantly changing its position in the crater, and so constantly raising cool carbon to the boiling point.

The question still remains, Why does not the evaporation cover the crater surface in the case of the short arc as in the case of the normal arc? With the idea that the vapour stream might have a certain geometrical relation to the crater, a system of measurements was begun on normal arcs, using the same current and quality of carbon. The measurements taken were on the diameter of crater, depth of crater, length of arc and diameter of the knob on the negative carbon. Fig. 5 is a diagrammatic section through an arc. The figures from which this was drawn were obtained by measurements of normal 10 ampere arcs, using a good quality of soft carbon. O P is, of course, the crater, and A B the negative tip or knob; O *m n* P is the vapour of the arc. The striking thing about this diagram is that C is the centre from which *m n* and O P are described. This, however, shows what might be expected, namely, that the arc burns away the carbon, so as to keep all points at an equal distance from each other.



FIGS. 5 and 6.—Diagrammatic sections through arcs.

When it comes to the short hissing arc the measurements are more difficult—that is, the measurements taken on the normal arc will not amount to anything because the vapour stream, as was said before, does not come off from the entire crater, but only from a part. Of course, exact measurements of the area of evaporation could not be made, but by examining the crater after the current was turned off the area of the evaporation surface, just before it was turned off, could be noted by the peculiar appearance of the crater. By taking a number of measurements in this way, accurate enough results were obtained to draught a diagram shown in Fig. 6. It will be seen that the angles *m* C *n*, in Figs. 5 and 6, are nearly equal, and I think it is safe to assume that if O H, Fig. 6 (the area of evaporation in the short arc), could be obtained with absolute accuracy, the angle at C would be equal in both cases. The diameter of the crater O P is smaller in the short than in the normal arc, but there seems to be a point beyond which the crater ceases to decrease in diameter to correspond with the size of the vapour stream.

At this point the evaporating surface not being confined to a particular area, the arc begins to hiss. It is manifest that as the arc shortens, the crater will become more and more concave, and of course, its edges will necessarily become sharper. The heat of the arc tends to wear away the edges of the crater; but as the arc is shortened and the cavity becomes greater, the edges do not wear away fast enough to keep down the crater surface. In the short arc the heat at the carbon tips is less than in the normal, and this fact will help to keep the crater edge from wearing. I use the word "wearing" to cover the three processes, namely, evaporation, combustion, and disintegration, which consume the carbon outside of the crater. By evaporation in the crater I mean the active boiling which takes place there, though evaporation in general does not imply boiling. The decrease of heat which accompanies the short arc can be accounted for by the decrease of boiling crater surface.

The wearing of the crater edges will also depend on the quality of carbon used, and this is one of the reasons why some carbons will burn quietly with a much shorter arc than others.

The facts brought forth here do not pretend to be the results of any elaborate investigation, as they are no more than can be found out by anyone with the use of an ordinary arc lamp. At any rate, it is safe to say that there is much yet to be written and discovered about the common every-day direct-current arc.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—TUESDAY, MARCH 29TH.

The Post Office and the Telephones.

On the motion for going into Committee of Supply on the Civil Service Estimates,

Dr. CAMERON rose to call attention to the relations subsisting between the Postal Telegraph Department and the telephone system, and to move:—

"That the Post Office system of granting licences to private telephone companies having resulted in the restriction of telephonic communication in this country, and a costly and inefficient service, this House is of opinion that, alike in the interest of the postal telegraph and the telephone service, the telephonic monopoly possessed by the Post Office should be worked directly and in connection with the Postal Telegraph Department."

After referring to the decision of Mr. Justice Stephen declaring that telephones were telegraphs within the meaning of the Telegraph Acts of 1863 and 1869, Dr. Cameron said he did not blame the Government for taking this course, because they were bound to protect, as far as possible, the ten millions of public money which they had expended in acquiring their telegraph rights. It must be taken into consideration that the Post Office telegraphs were at the present moment barely paying their working expenses, and that if telephonic competition was brought to bear against the telegraphs the Post Office must necessarily sustain heavy loss. But, on the other hand, if the Post Office authorities had acted in an ordinary prudent and businesslike manner, they would have been able to acquire all the rights of telephone inventors at a very reasonable rate, and thus have done a good stroke of business. The Government had already in existence a network of telegraph wires all over the country, and had suitable buildings and a sufficient staff at all the towns in the United Kingdom, and, therefore, if they had acted judiciously and with a due appreciation of the wants of the public, no private company could have hoped to compete with them. The Government, however, adopted a different course, and, instead of offering an equitable compensation to the telephone inventors, proceeded to set up some form of telephonic service themselves, and placed a crushing tax of 10 per cent. on the gross receipts upon the telephonic companies. The invention, however, was too valuable to be crushed by even such an exorbitant tax, and the telephonic service as supplied by private companies had extended in spite of that tax. In the meantime the 13 companies which were carrying on the service in the United Kingdom had come to a nice comfortable arrangement among themselves, which had resulted in the establishment of a great monopoly. The right hon. gentleman now proposed a policy the effect of which would be simply to consolidate and perpetuate the telephone monopoly which at present existed in this country. The result of the present state of things was the crippling of the progress of the telephone in this country. It had often been said that the telephone was the luxury of the rich; it had been made the luxury of the rich in this country by high charges and the high taxation of the Post Office. There was no reason why the use of the telephone should not be as general as the use of the telegraph, and why it should not prove much more useful to the poorer and the less educated classes of the community, who were not skilled in compressing their ideas into telegraphic form. When the public had once learnt the convenience of a good system of telephone communication they would not allow that system to be curtailed by the Post Office, and in self-protection the Post Office would be obliged to acquire entire rights over it. In 1880 the telephones might have been acquired for a few hundred thousand pounds; but the Post Office had continued putting off the inevitable step, and now, of

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course, a very much larger sum would have to be paid. In asking the House to affirm his resolution he was asking it to assert that the Post Office ought to do something to justify its monopoly, and to relieve the community of a system of dual control which had in the past wrought so much mischief.

Mr. HENNIKER HEATON in seconding the motion, said the present was a great opportunity for the House of Commons to strengthen the hands of the Postmaster-General by insisting that the entire system of telephonic communication should be taken over by the Post Office.

Sir A. ROLLIT said it was to be regretted that the house had not received longer notice that the question of the telephones was to be brought forward, as there was no question of greater importance to the community generally. He had had the opportunity in the London Chamber of Commerce and elsewhere of ascertaining very clearly the wishes of the community in regard to the telephones, and he did not hesitate in the least to say that the general feeling was that, not only might the present telephone service in England be improved, but that it would bear no comparison with the development which it had attained in other countries Of course, at the present time a much larger capital sum would be required for the purchase of the telephones than would have been necessary some years ago. He thought that the Government ought to do for the community that which it could do better and more cheaply than individuals could do for themselves. He believed the telephone would be, if not cheaper, better conducted by the Post Office than by the telephone companies. The great objection was that the principle was being carried too far, and the impression was that the commercial community had been taxed for the benefit of the Post Office. This was the system against which protests were raised, and he thought a very decided protest would be raised against the appropriation of the returns merely to revenue. What the country wanted was the best and cheapest form, and that was why he supported the principle.

Mr. LABOUCHERE agreed with his hon. friend that monopolies had their duties, and in this case the question seemed to be whether the State should impose conditions on private companies or do the work itself. The hon. gentleman opposite had elaborated a very interesting Socialistic view of the duties of the State. He agreed with him generally, but he would point out that this was essentially a luxury of the rich. He remembered speaking to Mr. Raikes, who pointed out that personally he was in favour of taking up the whole thing; but the Treasury was not in favour of it, owing to the great expenditure, which, for, say, 200,000 subscribers, would require an expenditure of £8,000,000. Therefore it was a matter to be seriously considered. From the general statement the Postmaster-General made the other day, he felt the Bill met a very difficult question very fairly.

Mr. QUILTER said he felt it his duty, as a Director of the National Telephone Company, to reply to some of the statements that had been made. It was wonderful that the Company with which he was connected had developed to such an extent seeing the hindrances with which it had had to contend, and that it had to do all its business on sufferance. During last year 160 million messages, at a cost of under ¾d. a message, had been transmitted over the wires of the Company. That was on the basis of each question and answer being two messages. With regard to the question of inefficiency, and on the question of the trunk wires being unremunerative, he would point out that in one day between Liverpool and Manchester 42,000 messages were sent. Again, when the Company opened its exchange in Leicester in July, 1890, Her Majesty's telephone office had 130 subscribers. The Company's exchange had now been opened 18 months, and there were 275 subscribers, while the subscribers to Her Majesty's office, which was said to be so much better conducted, had fallen to 100. Yet the Company had not the same privileges the Post Office had. He could not understand how, in a free country like this, the man who was a licensee and paid 10 per cent. of his profits to the Government, should not be entitled to the same privileges of communication with the post-offices as the subscribers to Her Majesty's Post Office. In spite of all its dead weight, the Company had made marvellous way. He admitted that the service in London fell far short of what was wanted. But the Company would be perfectly able to do the work if the Post Office would delegate to them those powers which he humbly contended every licensee of the Government ought to possess.

Mr. GRAHAM said this did not appear to him entirely a question of profit and loss. In spite of the statements of the hon. member who had just spoken, he held that it was best for the community at large that all means of communication should be in the hands of the State.

Sir J. FERGUSSON said that in the statement which he had made a week ago the Government had desired to take the House completely into their confidence by explaining the scheme which they had in view, and the Bill which would be introduced would by no means cover the whole scope of that scheme. The matter was one which, if properly handled, would really conduce to the prosperity of the country. The course previously taken by the Post Office with regard to this matter might or might not have been the best one. Telephones might have been conveniently conducted along with the telegraphs, to which they were really akin; but that course had not been taken, and they had to deal with existing circumstances, involving a considerable amount of inconvenience. On the one hand, a considerable property had grown up in the hands of licensees of the Post Office, while, on the other, that system had failed to produce such an extensive use of this most useful invention as had been anticipated by the Government, and as had been the case in other countries. He thought that it was altogether unjust to hint that the object of the Post Office had been to stifle invention. No man, for instance, could have been more disposed to encourage invention than the late Mr. Fawcett. It was not correct to say that the Post Office had plundered at once the companies and the inventors. That was altogether a misapprehension of the facts of the case. It had been asserted that the Post Office had acted capriciously in the matter of granting licences. There had no doubt been different policies at different times, and applications had been dealt with under those different policies. But it could not be said that licences were granted too sparingly when they had been granted to 13 companies. In determining now not to grant licences in a wholesale way, the Department was, in his opinion, quite right. Nothing could be more erroneous than the suggestion that the possession of the trunk lines by the Government would be detrimental to competition. It was, on the contrary, the very circumstance likely to encourage competition. A new company with no trunk lines could not compete with an older company that had trunk lines. It was the object of the Government, after having established trunk lines, to connect together the local exchanges in every part of the country. Whilst the Government proposed that the companies should be allowed, by becoming connected with the Post Office, to achieve a new development in their industry, they only intended to grant the privilege to companies that were ready to join in a system of free and unrestricted communication. Complaint had been made of the royalties which companies were made to pay, but the sum paid had never exceeded £46,000 in a year. This could hardly be deemed an extravagant figure when it was borne in mind what dividends the National Company was paying. The great development of telephonic communication in Paris had been alluded to. Under the Paris system there was no restriction upon free communication with the Post Office, and it was the very system which the Government desired to establish in this country. Having acquired the trunk lines and mains, the Government would be able to promote free competition and the commercial development of telephones. They were in possession of a telephone between London and Paris, which was doing very satisfactory work. They had found it necessary to establish a second metallic circuit; there were 120 conversations a day, and the charge made was 8s. for three minutes' conversation. He anticipated that, when the Government should have completed their system, there would similarly be constant conversations between all the great towns in England. The Post Office possessed the right of laying down underground wires in towns. These wires they would let to the Companies for the development of their exchanges, but this arrangement as to mains was not essential to the scheme. The desire of the Post Office being to facilitate the work of the companies' exchanges, they were ready to undertake the laying down of wires in towns. He recognised that this country owed much to companies, and it would, in his opinion, be most short-sighted and ungrateful to treat all companies as if they were leviers of blackmail, or sharks, or monopolists. The Government had no desire to restrict unduly the operations of the companies, which they hoped would conduce to the public service; and, therefore, they were willing to place a liberal interpretation upon the agreement as far as the areas within which the companies might lay their main wires were concerned. The hon. member for Canterbury had expressed his desire that the Government themselves should take over the telephones, and, following the example that had been set with respect to the telegraphs, should make them national undertakings. He was afraid, however, that such a proposal would be a very far-reaching one. He did not suppose that in order to carry out a telephonic system anything like the large capital that had been invested in the telegraph system would be required; but, at the same time, the House would hesitate before it authorised the Government to largely increase its Post Office capital or the number of people in the Post Office employment. He thought that it was undesirable that there should be a direct employment by the State of a great number of *employés*. He submitted that the Government had acted prudently in endeavouring to restrict the number of persons in their employment, as long as the public service was efficiently provided for. In these circumstances the Government had resolved not to acquire the capital of the companies, but to permit them to continue to carry on the services under their licences. Turning to another point, it was quite evident that there would be a number of telephonic districts which would not pay if they were in the hands of the Government. Of course, if it were desired that both the telegraph and the telephone systems should be carried on by the Post Office, irrespective of the amount of profit revenue to be derived from them, the public want could be easily provided for. No doubt in certain of the Australian colonies the Government undertook to work the telephone service as they undertook to work the railways; and, perhaps, in an undeveloped country it was desirable that the Government should undertake many matters which could be better managed in this country through private companies In this country the work could not be done as cheaply by the Government as it could by private companies, and he did not think that even in Australia the undertakings had been commercial successes, it having been found necessary in that part of the world to reduce the accommodation on the railways and to increase the fares. It was for these reasons that Her Majesty's Government had not thought it prudent to undertake this great additional service, and had decided to leave the working of it to private companies. Her Majesty's Government, in these circumstances, felt bound to oppose the motion of the hon. member. With regard to the profit revenue that was likely to be derived from supplying the public demand for a telephonic service, it was a remarkable fact that an extension of the service beyond a certain point involved a reduction of revenue. A Director of two American telephone companies had informed him that it sometimes took three years of the amount of a subscription to pay for a fresh installation, and that it was not until the lapse of that period that any profit began to be derived from the particular subscriber. These things ought to operate as some excuse for the companies not having brought the cost of their service within what some would call reasonable bounds. He would, however, try to improve the system, and he was bound to say that in a short time telephone communication would proceed at a rate hitherto unknown. There were one or two points upon which there was some misapprehension which it was desirable should be removed; and if he opposed the motion of the hon. gentleman, he thought it right to show that the offer of the Government was not illusory, and that they had the

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same object as the hon. gentleman had at heart. They proposed that telephone communication should be established as widely as possible between one part of the country and another. There was no reason why new companies should not be formed to create new exchanges. He had not the least doubt that in a very short time we should hear of the establishment of new companies and new exchanges, although the existing companies could establish new exchanges with special advantages. And behind the companies was the power of the Government to erect telephone exchanges. Undoubtedly, if people desired to have telephone exchanges in their towns, and could not conveniently establish companies of their own, or if the existing companies did not supply their wants, the Post Office would come in as at Newcastle and Hull and supply telephone exchanges and perfect the system between towns. The safeguard for the taxpayer was that any profits derived from this action of the Government would be in the hands of the Post Office and would go to the direct benefit of the revenue. No part of this policy required the sanction of Acts of Parliament; all these things were entirely within the existing powers of the Government. They were a new development of the system already pursued by the Post Office under the authority of Her Majesty's Government. But undoubtedly the House of Commons would have to be consulted with regard to the mode of carrying out the system; and as there would be an increase of the Post Office vote *ad hoc*, Parliament would be asked to endorse the action which might be proposed. The Government intended to relieve the cost of the heavy obligations which rested on the companies for way-leaves. He believed and he hoped that competition would not be diminished, that profits would not be decreased, and that all would share in the advantages of the extension of the system which was so much desired, and which he was satisfied would place this country in as full possession of telephonic invention as any country in the world.

Mr. PROVAND said that the telephone had become the monopoly of the Government some years ago, but they had licensed 13 companies, out of which only three or four survived at present. The Post Office had the option of buying up these companies only every seven years, and the next opportunity they would have would be six years from the present time. The question had been actively before the Post Office for the last 18 months, and some measure ought, before now, to have been submitted for the consideration of the House. He could not vote for the motion of the hon. member for the College Division. That motion meant that the Post Office was to start telephonic exchanges in opposition to those of the companies to whom licences had been issued; and that would not be equitable, because the companies already paid a 10 per cent. royalty to the Post Office. If the motion had not that meaning, it meant that the Post Office was to buy up the telephone exchanges, and he could not support any such proposal unless it were accompanied with the terms on which the purchase was to be made.

The CHANCELLOR of the EXCHEQUER said that as the matter under discussion so deeply concerned the finances of the country, the House would perhaps allow him to supplement the statement which had been made by his right hon. friend. The Executive Government and the Civil Service might well congratulate themselves on the fact that the House was so very ready to trust a vast new business to the management of a public department. It might have been thought, in view of the many complaints which had been made of Post Office administration, that any proposal to extend the operations of that department would have been severely criticised by the House. But it was evident that, in spite of these complaints, the House placed considerable confidence in the Post Office, and was not afraid to give into its hands a new and increasing business. But that principle ought not to be pushed too far; and he was not prepared to accept in an indefinite degree the constant placing of new duties upon the State. The Postmaster-General was at present at the head of an army of 100,000 men; and no one ought to look with a light heart on the unlimited increase of such a vast army. The House ought to be extremely careful before asking the Government to put its hand to new work of such vast dimensions. It was not a Post Office question, so much as a question of public policy. The scheme of his right hon. friend would show the House to what lengths the Government were prepared to go. The hon. member who had spoken last had raised two very pertinent questions, in referring to the alternatives of buying up the telephones or of competing freely with the present companies. Of course it would be impossible for the companies to compete with the Government; and if the Post Office took action on its own account, it would be necessary to make some money payment to the private companies. He remembered the purchase of the telegraphs, and he shuddered at the recollection of the enormous price which the Government had to pay for them. The public at that time were determined that the telegraphs should be taken over, and the Government could not proceed with sufficient caution. He did not wish the Government to be placed in a similar position with respect to the telephones. They offered to the public a plan which combined the simplicity of Government control with the expansion to be expected from private enterprise. His right hon. friend had explained how the trunk lines would be taken over by the Government, leaving to the localities the working of the local exchanges. If that were done, he believed that the public would be better served than if the Government were to take over the entire system; because there would be a competition in the localities to serve the public as well as it could be served. The attitude which the Government would then take up towards the local authorities would insure that if a town was badly served there would be another Company to meet the want; while if the town were sufficiently served there would not be the inconvenience of multiplying wires and taking up the streets which was inevitably attendant upon the establishment of competing companies. It had been suggested that the local authorities themselves might be willing to undertake the telephone business; and he saw nothing to contradict the Government's policy to such a proposal. If there were a town in which a telephonic system had not been established, and in which the local authority wished to undertake the system, there was no reason against such a course, the communication with the rest of the country being established by the trunk lines in the hands of the State. It was absolutely necessary that the Government should take the trunk lines into their hands. If that were not done they could not have that competition which it was desired they should secure. While the National Company had a monopoly it was impossible for the other lines to compete. A telephone circuit was only half useful unless it was put into telephonic communication with the rest of the country; and unless that were done the people of a locality not in communication with the whole of the country would be only half served, and therefore it was why in one sense the Government would have to take the trunk lines into their own hands as a means by which to secure free trade. On the other hand, they wished the local authorities to exercise supervision. He did not know whether the House was aware of the powers which the Government possessed in this matter, but the powers rendered it unnecessary to introduce a fresh Bill. In the licence which was granted it was clearly provided that nothing in the licence should affect the right of the Postmaster-General to establish, maintain, and work any system of telegraphic communication as he shall in his discretion think fit. Therefore, the licensees had been warned that the Government retained the power in their hands. He thought that it would be evasive of the spirit of the licence if during the continuance of the licence they took the whole of the telephonic arrangements into their hands to the detriment of those who on the faith of the licences had been extending the system up to the present moment. This was the compromise they offered, and he thought they had gone a long way. They had great confidence that they should be able to work the system with great elasticity, though he was fearful of the effect of the telephone on the telegraph revenue. But they had come to the conclusion that financial considerations ought not to prevail against the extension of the telephonic system, which was considered by the public to be a convenience.

Mr. ROBY hoped the mover of the resolution would press it to a division. He thought the Chancellor of the Exchequer would find that in the long run he would have to go a step further, and that the only difference would be that the interest they would have to purchase would be much greater than it was now. As the telephones were competing with the telegraphs it would be better to make a good mouthful of the business.

The House divided, and the numbers were—

For Dr. Cameron's motion	147
Against	205
Majority against.....	—58

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, April 1st.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert at St. James's Hall Restaurant.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Motion of the Ether near the Earth." By Prof. Oliver Lodge, F.R.S.

SATURDAY, April 2nd.

INSTITUTION OF CIVIL ENGINEERS.

6.30 p.m. Annual Dinner of the members, in the Town Hall, St. Martin-in-the-Fields, Charing Cross Road.

MONDAY, April 4th.

SOCIETY OF ENGINEERS.

7.30 p.m. "Electrical Traction and its Financial Aspect." By Stephen Sellon; conclusion of discussion. A Paper will afterwards be read on "The Application of Electricity to Hoisting Machinery." By Reginald Bolton.

TUESDAY, April 5th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary meeting. Paper to be read: "The Sewage Farms of Berlin." By H. Alfred Roechling, Asoc. M.Inst.C.E. At this meeting the monthly ballot for members will be taken.

WEDNESDAY, April 6th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "The future Trade Relations of Great Britain and the United States." By Robert McCornick, Resident Commissioner for Great Britain from the World's Columbian Exposition.

THURSDAY, April 7th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. "Load Diagrams of Electric Tramways and the Cost of Electric Traction." By A. Reckenzaun, Member. Continuation of discussion.

FRIDAY, April 8th.

PHYSICAL SOCIETY.

5 p.m. Ordinary meeting. Papers to be read: (1) "Note on a Law of Colour in its relation to Chemical Constitution." By William Akroyd. (2) "On the Construction of a Colour Map." By Walter Baily, M.A. (3) "A Mnemonic Table in connection with Electrical Units. By William Gleed, M.A.

ROYAL INSTITUTION

9 p.m. Evening Discourse: "Electric Meters, Motors and Money Matters." By Prof. W. E. Ayrton, F.R.S.

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The Electrician.

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THE LANE FOX CASE.

It is not until an important Patent Case has dragged on through the Courts of Chancery and Appeal and the House of Lords that it can be said to be over; and even this routine may be varied by the ordering of a new trial. But we are permitted by custom to comment upon it after judgment has been delivered, whether the usual course in such important cases is proceeded with or no. The judgment, which was delivered on Wednesday last, went against Mr. LANE FOX, in the first place on the ground of disconformity between the provisional and the final specifications as amended. It was decided that the system described in his patent was impracticable; that during the thirteen years which had elapsed no practical examples of its use could be pointed out; and that an intelligent workman could not successfully carry out the instructions without experiment and further invention. The "earth" was the only point which was given in favour of the plaintiff.

There are four points of view from which the Lane Fox case may be regarded,—the historical, the scientific, the moral, and the commercial. Historically, the use of the term "earth," the various attempts to use earth return in practice, and the details of the earliest examples of incandescent lighting, were interesting; but the important feature, and one about which much more might have been told if it had entered directly into the recent lawsuit, was the discovery of the parallel system of distribution. It cannot be denied that in the interval between the filing of Mr. LANE FOX's provisional specification, 3,988, 1878, and of the final, the whole assembly of scientific men who gave evidence on the practicability of electric lighting before the Select Committee of the House of Commons were intent upon arc lighting. It is all very well to say that there were no glow lamps worth considering, and that if there had been "there would have been no difficulties." The recollection of COLUMBUS and the egg is irresistible. Of course, the connection of circuits in multiple

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arc, as it was called, was well known to telegraphists; but the idea of low-resistance mains with a constant difference of potential, and high-resistance glow lamps, was conceived by LANE FOX as a practical system, and proved to be so by him, in spite of the incredulity of dozens of scientific authorities who thought that the whole current would run by the shortest route through the first lamp. Not only was it proved to be practicable, but the whole of our present glow-lamp distribution is the result. WOODWARD and WERDERMANN had suggested parallel working; but Mr. LANE FOX did something more: he showed that the principle was sound and practical. But a principle cannot be patented. On page 290 of the first volume of the present series of *The Electrician*, Nov. 9, 1878, the Werdermann lamp is illustrated and described: "The method of dividing the lights is that known and used to so great an extent in every branch of electricity, viz., 'the multiple arc system.'" But we find that early in 1879 the following statements were made at a lecture at the United Service Institute: "The ease with which a wire can be maintained incandescent has led many to believe in the possibility of the extreme subdivision of the light. There is, however, no difficulty in showing that this hope is quite inadmissible, according to our present knowledge . . . It is easily shown that in a circuit where the E.M.F. is constant and we insert additional lamps, then, when these lamps are joined up in one circuit, *i.e.* in series, the light varies inversely as the square of the number of lamps in circuit; and when joined up as in multiple arc, the light diminishes as the cube of the number inserted. Hence the subdivision of the light is an absolute *ignis fatuus* . . . Although the extensive subdivision of the light must be ranked with perpetual motion, squaring the circle, and the transmutation of metals, yet no one will say it is 'impossible;' but all must say 'not yet.'" So anxious were our eminent electricians to shelter an ignorant public from the chimerical schemes of inventors! A collection of the criticisms of the day on incandescent lighting would be very amusing. One serious objection was based on the C^2R law; we remember hearing this enunciated at the time, but it is as difficult as a dream to reconstruct from memory The recent trial has not shaken Mr. LANE FOX's claim to the discovery of the practicability of parallel distribution at constant pressure, but, on the contrary, has established his position on surer grounds.

It is difficult to point to any one prominent scientific feature in this case. The weakest point of the plaintiff seems to have been in the liability of secondary batteries to sulphation unless occasionally charged up to 2·5 volts per cell. It was rather rash on the part of his witnesses to suggest that any useful charging can be effected with a one per cent. increase of pressure. The questions at once arise—one per cent. above what? and how is the one per cent. measured? Can it be done except on a laboratory scale? From one point of view this was fatal to the plaintiff's case; but the ATTORNEY-GENERAL put forward the most ingenious argument that, while it is desirable to keep the batteries in health, and while recent knowledge has shown how this may be done, nobody suggested that the cells act differently when they are in that condition, and that it had no relation to the use of batteries either as reservoirs or as regulators. As soon as it was known that batteries ought to be occasionally charged up to 2·5 volts per cell, the use of switches for altering the number of cells was an obvious improvement. Experiments were carried out during the trial by Mr. LANE FOX's friends to show that charging and discharging could be carried out within the Board of Trade limits of variation of pressure; but the results were not put in, and wisely, we think, since the necessity for thorough charging ought to be frankly admitted. The experiments, however, were in themselves interesting; and we hope, on a future occasion, to publish the results. Of the scientific aspect of the earth-plate question there is little to be said. The rather hasty guess of Prof. PERRY is more pardonable than the suggestion that a coil of bare wire thrown into a river would form a good earth-plate. Its effective area would of course be about the same as a disc of metal of the same diameter. Still more misleading was the twice repeated tale that no current whatever could be induced to pass through an earth return; for the Judge could not be expected to understand, unless the point had been carefully explained, how the fact that in both cases a series-wound dynamo was used, completely explains the failures.

It was not the business of the Court to consider the moral side of the question. This ceased indeed to be anybody's business as soon as the Lane Fox Electric Company began to take legal proceedings. When Mr. LANE FOX first employed a firm of Westminster engineers to negotiate with the Brush Company for the re-assignment of the patent, no exorbitant demands were contemplated. The inventor of the application of the system of parallel working at constant pressure, in combination with secondary batteries, was, we think, morally entitled to some recognition and remuneration, in spite of the fact that he assigned away his legal rights to an apathetic or adversely interested company. The suggested sum of £300 a year for two years from the Kensington Company, and a like sum from the others, would not have been oppressive; and if private consumers had been let alone and if straightforward arrangements had been made through a solicitor, it is not improbable that the affair could have been settled. Mr. CROMPTON on the other hand has something to say. He acknowledges Mr. LANE FOX's early inventions; and admits, we believe, that our modern methods are the outcome of them. But the present system, as exemplified by the usual arrangement of machinery and apparatus, has not grown of its own accord; it has been the fruit of years of hard work, of thousands of pounds spent, of continual experiment, and of accumulated experience. Mr. LANE FOX, in Mr. CROMPTON's view, has contributed to none of these, while he claims that the result is his; and that the elaboration, to which Mr. CROMPTON justly points with pride, consists of more or less useless and adventitious complications. Mr. LANE FOX's moral claim and perhaps his legal case would have been strengthened by the acknowledgment of the improvements which have been brought about since he ceased to concern himself with secondary batteries.

The mention of the terms which were asked by the Lane Fox Electrical Company brings us to the commercial point of view. At a meeting held in July, 1890, it appeared that the royalty asked from supply companies was one farthing a unit for the two remaining years of the patent, amounting, in the case of the Kensington and Knightsbridge Company, to £300 a year. Some such sum as this might fairly have been paid; but 1s. 6d. per lamp was being asked from owners of plant for private houses, and 2s. 6d. per lamp for clubs, hotels, &c. This was not only a much more serious demand, but it was peculiarly vexatious, since such users could not be expected to know anything about the existence of the patent, or even of the talented inventor himself. It is doubtful whether previous to the opening of negotiations after the conclusion of the litigation between the Brush and the Edison-Swan Companies, there were twenty persons in this country who knew that the patent was still alive. Such resuscitations are very rare, or there would be ample justification for an extension of the statute of limitations to such cases

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However much the industry may have been indebted to Mr. Lane Fox, his equitable right to demand oppressive royalties has been greatly diminished by the absence, during the past ten years, of any demand for payment, or warning that a claim might some day be made. Royalties on various scales were proposed from time to time, and these will be found recorded in the earlier numbers of our twenty-fifth volume. During the negotiations, the annual royalty demanded from the Kensington and Knightsbridge scapegoat rose to one penny on each unit sold, equivalent to some £1,200 on last year's output. For the suggestion of this exorbitant sum we believe Mr. Lane Fox has to thank his commercial advisers. It was this that compelled the supply companies to form a Defence Association, and it was this that has led to the waste of time and money on litigation.

The subsequent patents of Mr. Lane Fox are full of the development of details, and show a wonderful foresight which has been recognised both by the opposing counsel in this case and by the Judge. But some of these have lapsed, and others were bad and would have needed a serious amount of pruning by disclaimer. No. 4,043 of 1879 contains amongst other suggestions the method of heating water by an enamelled wire placed at the bottom of the vessel, the very plan now adopted in the electrical cooking demonstrations at the Crystal Palace. But electric lighting was in its infancy in those days, and it was practically impossible to protect so wide a system as that of parallel distribution except by a vast number of patents for details; and details such as those on which important patent cases have been won are rarely to be found in the patents of Mr. Lane Fox. It is perhaps well that broad patents are difficult to secure, and that principles cannot except in very rare instances be patented. Monopoly in such cases generally offers a serious impediment to trade. To restrict the facilities offered by the Patent Office would be to restrict the exercise of inventive faculties; but principles are discovered, not invented, and the making of discoveries cannot be checked. Unlike invention, discovery needs no artificial stimulation; when the time is ripe for a new scientific revelation it will, in the nature of things, be made, if not by one particular man, then by some other. In 1878 the world was not ready for parallel distribution. To Mr. Lane Fox belongs the honour of the discovery, and essential parts of it are the high-resistance filament and the constant potential.

REVIEWS.

"Modern Practice of the Electric Telegraph." By F. L. Pope. (New York: D. Van Nostrand Company.)

If there is any advantage in a new work on a subject already flooded by text books, it may exist in a more lucid manner of treatment, or in the pieces of practical experience the author gives by way of leading his readers on step by step. We find nothing beyond the mere text book style in the first six chapters, treating on the Sources of Electricity, the Theory of Quantitative Electrical Measurement, the Laws and Conditions of Electrical Action, and the Laws of Electro-Magnetism. One oasis appears in the fifth chapter, where directions are given how to construct a tangent galvanometer, but this the author gives as "taken in part from S. R. Bottone's 'Electrical Instrument Making for Amateurs.'" On page 61 we find the words: "From the above explanations and examples it will be seen that a standard galvanometer may be constructed from which it is always possible, knowing the force of the earth's magnetism, to determine the value of any electric current in amperes." Looking back for these explanations we find nothing of the kind of information the student wants. He would want to know whether it was worth his while to start making such an instrument; and, if so, some directions as to proper proportion of size of coil, size of wire, and size of needle, &c., and some hints as to how to start about it, and what to do with it when completed. Finding no "explanations," we turn to the theoretical "examples," and find that, "given the number of turns, and the mean radius of the coil of the tangent galvanometer, the observed deflection, and the horizontal force of the earth's magnetism at the place of observation to find the current in amperes," the following rule must be applied:—"Multiply together the mean radius in inches, the tangent of the deflection, and the magnetic force of the earth in dynes, and divide the product by the number of turns in the coil. The quotient is the current in amperes." This can only be characterised as the most careless and misleading, not to say ignorant, treatment of the subject. To put inches instead of centimetres after the disquisitions on pages 36 to 38, on the C.-G.-S. system of units, may be passed over lightly in comparison to the error of putting the C.-G.-S. unit of current as equivalent to one ampere. But the case is even worse when the constant 2π is omitted, for it leaves the statements, rules, and examples absolutely devoid of reason. It is a relief to turn to chapters VII., VIII., and IX. on telegraph circuits, the equipment of American telegraph lines, and testing telegraph lines, where the author is apparently more at home, and where some good practical data are given as to the working of lines which the American telegraphist should find useful. But the author fails, even here, to give any precise details. The Blavier test, given on page 202, is dismissed by saying that "it presents some difficulties for the reason that the resistance of the fault is usually variable." There is nothing original in the illustrations, which are wearying to look upon, so often appearing and re-appearing in different works; and, with the exceptions named, the book can only be regarded in character as general and superficial.

"Electricity up to Date." By J. B. Verity. (London: F. Warne and Co.)

A rather rash title has been chosen by Mr. Verity, who thus lays himself open to any amount of criticism; but the little book is accurate enough for the purpose, which is to add one more to the host of popular books on the subject. With a mistaken modesty, the author has omitted all reference to cost of wiring and fittings and price of electric supply, matters on which he is so thoroughly competent to deal, and on which his opinion would be worth having. The scientific part is rather weak, and contains such statements as the following: "The points of the carbon rods become highly incandescent, and, in addition, the space between them is filled by a sort of flame or cloud of particles of white hot carbon. From these particles of incandescent carbon, forming as they do one dazzling mass of brilliancy, more light is emitted than from the points of the carbons themselves." He reproduces the illustration which appeared in Deschanel's book some fourteen years ago, and has done good service in more than half the books on electric lighting which have been published. It is hardly necessary to say that no such cloud of particles appears in the excellent illustration. A good summary of the supply companies is given, together with a coloured map of the London districts.

The Occlusion of Hydrogen by Nickel.—In *Il Nuovo Cimento* (Vol. XXV., p. 222) MM. Bellati and Lussarra describe some interesting investigations carried out by them in connection with the occlusion of hydrogen by nickel. The experiments were carried out with nickel wires used as negative electrodes of a voltameter. After a current had been passed through the voltameter for 200 hours one of these wires had absorbed about 100 volumes of hydrogen. The occluded hydrogen was not given off freely; on the contrary, the wires became oxidised on exposure to the air. While the process of occlusion was going on the wire elongated in eleven days by ·000036 of its length, so far as could be ascertained. The resistance of the nickel augmented as occlusion went on, its temperature coefficient diminishing.

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MATHER AND PLATT'S ALTERNATOR.

Messrs. Mather and Platt, of the Salford Iron Works, Manchester, have recently constructed two large alternate-current machines for a central station for lighting the borough of Redfern, Sydney, New South Wales.

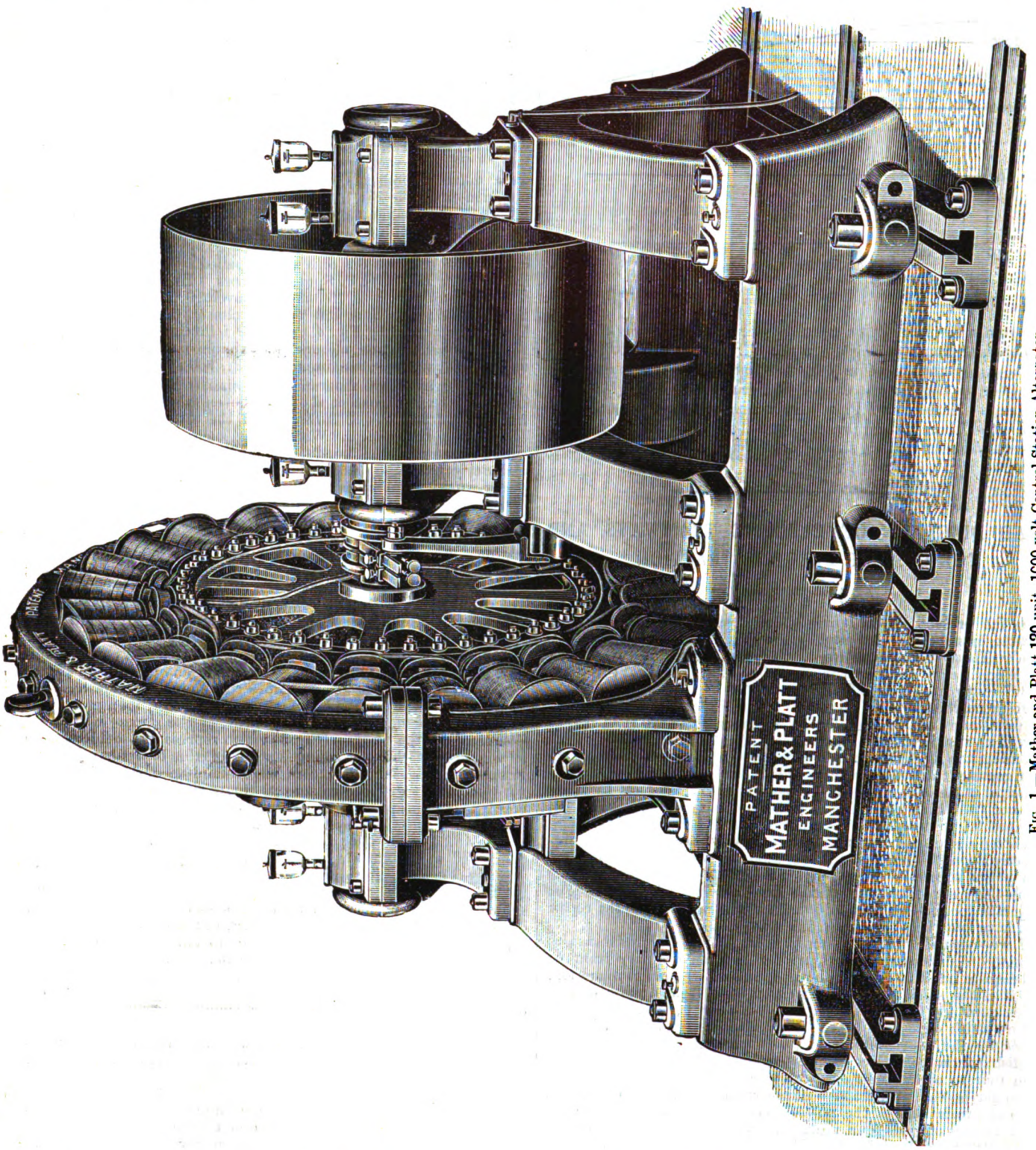

FIG. 1.—Mather and Platt 120-unit, 1000 volt Central Station Alternator.

As is the case with most alternators in which the cores of the armature are of iron, the armature revolves, and the magnets are fixed. The magnets are of wrought iron, and arranged round the armature exterior to it, and are attached to a massive cast-iron ring, which forms the yoke connecting the limbs. The attachment is so arranged that any of the magnet cores can be removed without disturbing the remainder or taking out the armature. The yoke ring is made in halves, so that the upper part may be lifted to allow of the easy removal of the armature.

The armature itself is constructed of two plates or discs keyed on to the shaft, between which the armature cores are held by bolts. As is the case with the magnets, any section of the armature can be removed without disturbing the remainder. Apertures in the discs allow free ventilation of the interior of the armature.

The machines in question (*see* Fig. 1) are manufactured under the patents of Dr. John Hopkinson and Dr. Edward Hopkinson, and are designed for an output of 120 kilowatts, at 1,000 volts, when running at 400 revolutions per minute. There are 24 poles, so that the number of reversals is 9,600 per minute, corresponding to a frequency of 80. The resistance of the magnets is 16 ohms, and of the armature 0·11 ohm, and the exciting current is 5 amperes.

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Careful tests have been made on the commercial efficiency of a similar machine of somewhat smaller size by driving it from a motor of known efficiency and absorbing the power generated by the alternator in a non-inductive water resistance. These tests show a commercial efficiency of 92 per cent. The fall in

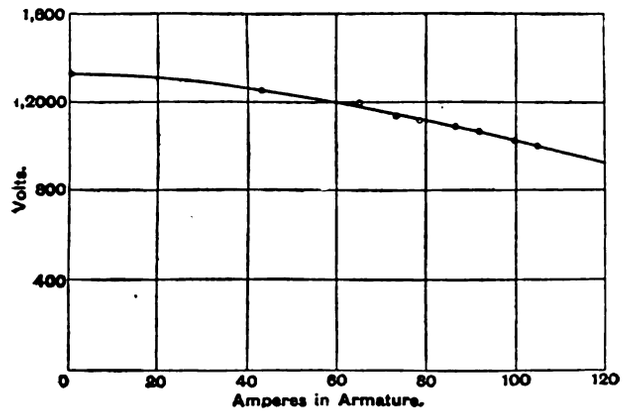

FIG. 2.—Curve shewing fall of volts as load increases.

electromotive force with a constant exciting current as the load is increased from nothing up to the full current of 120 amperes is shown by the curve in Fig. 2. In practice this is compensated for by varying the exciting current.

Messrs Mather and Platt have constructed a considerable number of these alternators for central-station work, and make the machines in various sizes, from 16 kilowatts up to 200 kilowatts.

LOAD DIAGRAMS OF ELECTRIC TRAMWAYS, AND THE COST OF ELECTRIC TRACTION.*

BY A. BECKENZAUN.

In the present Paper I propose to draw attention to two important branches of this rapidly growing subject, "electric traction." These branches relate to the energy consumed in propelling electric cars, and the commercial results of several tramways in different parts of the world.

Of the errors into which the pioneers in electric traction fell none was more serious, and I may say more general, than that of providing insufficient motive power. The early motors were all too small, too lightly built, and consequently were not durable. In spur gearing, the double-reduction gear has been abandoned by the principal American firms on account of its great cost of maintenance; the high speed at which the motor pinion had to run was detrimental to the life of the mechanism. A reaction has set in, and attempts are being made to drive cars by placing the armatures directly upon the axle. It is questionable whether this method will prove successful in the long run. But the single-reduction gear—that is to say, one pinion and one spur wheel running at moderate speeds—appears to give excellent results, and the repair bills have been largely reduced in consequence.

If we calculate from the accepted coefficients of resistance to traction on common tram rails, we find that an ordinary tram-car will require but 3 to 4 H.P. for its propulsion when once in motion. But it is the setting of a vehicle in motion from a state of rest which demands the greatest amount of energy; and the electric motors which were built in the early days were soon knocked to pieces by the enormous strain put upon them on starting. On English tramways, it has been computed, a tram-car has to stop from four to eight times every mile, according to the amount of passenger traffic. With a view of ascertaining the exact conditions as to the variations in the power consumed on an electric car, I made a series of tests four years ago with an electric car in the public streets of Philadelphia. Fig. 1 represents a portion of a diagram obtained from careful readings with reliable instruments. The whole trip lasted 71 minutes, but the diagram (Fig. 1) represents only the first 19 minutes. Readings were taken and recorded every three seconds. The maximum current, it will be observed, reached at times 120 amperes. This occurred when starting on curves and gradients. Frequently it dropped to zero, and, in fact, these gaps, representing periods when no current was used, gave, on being added up, 45 per cent. of the total. The car contained 84 storage cells weighing 3,400lb., and it carried an average of 26 passengers. The aggregate weight propelled was 7 tons. The distance covered during the entire journey was 7 miles, giving a mean speed of only 6 miles per hour; and this had to be maintained on account of the horse cars which ran on the same line. Averaging the current consumed, we find it to be 31 amperes. The maximum E.M.F. was 160 volts, and the mean 157 volts, giving an average of 6·52 E.H.P. used by the car motor. The maximum current of 120 amperes into the minimum E.M.F. of 140 volts would give 22·5 E.H.P.; but this occurred only nine times during the journey, and each time but for a second or two. Currents of from 60 to 100 amperes were recorded more frequently.

The next three diagrams are exceedingly interesting, as they represent the working of three different systems of electric cars on an overhead conductor line at Des Moines, U.S.A. These tests were made on the same day, over the same length of track, with the same number of passengers carried, and the same kind of car body The cars were operated by the same man, and the readings were taken by officials of the tramway company. Fig. 2 was obtained from the car fitted with two 15-H.P. Thomson-Houston motors. The maximum current at any time was 75 amperes, the mean 22·4, dropping at times to zero, while the E.M.F. varied between 360 and 520 volts on a run of 20 miles. Fig. 3 gives the curves from observations on a car propelled over the same distance by means of two 15-H.P. Sprague motors. Here again we observe a maximum current of 75 amperes, average 25·95 amperes, with E.M.F.'s varying from 320 to 560 volts at the motor terminals. Tests, represented by Fig. 4, gave the following results with two 15-H.P. Westinghouse motors:—Maximum current, 95 amperes; mean, 31·3 amperes; maximum E.M.F., 560; minimum, 360.

I could give more diagrams of a similar kind, but these will suffice for the purpose of showing the enormous and remarkably frequent fluctuations of current, and the attendant rise and fall of the energy consumed. With several such cars running on a line with overhead or other conducting medium for the transmission of electricity from the generating station to the moving cars, the peaks would occur at more frequent intervals, filling the great gaps in proportion to the number of cars running simultaneously. Little reliance, however, should be placed upon the possibility of obtaining even a moderately constant load at the generating station. From numerous experiments, I have found that it takes about 20 seconds to bring a tram-car from rest to its normal speed; during this period the current drops gradually from its maximum, due to the ohmic resistance of the circuit, to a value corresponding with the load upon the car motor at its normal speed. The stoppages on tram lines with much traffic are so numerous that it will often happen that a large percentage of the cars start simultaneously, when for a moment the engines and dynamos have to exert their utmost power, and before the engine governor has time to act the current may be down again at, or below, its normal.

I am indebted to Mr. Gibson Carey, of the Thomson-Houston Company, for the diagram (Fig. 5) which represents the fluctuations of the load at the generating station of the Roundhay Electric Tramway at Leeds. Five cars were simultaneously on the line, yet the current dropped to zero 20 times within the space of one hour. These abrupt changes have the effect of reducing the average efficiency of the whole system to a comparatively low figure. The engine and dynamo must be able to furnish the maximum energy demanded at any instant, whilst the mean power in many cases scarcely comes to one-third of the maximum. Measurements made by Dr. Louis Bell on several American electric tramways have shown that the efficiency of an entire system, taking the B.H.P. of the car motors, divided by the I.H.P. of the engine at the generating station, amounts in some cases to only 25 per cent., and that in no case does it reach over 40 per cent. in every day practice on a tram line. With electric railways having fixed stopping places at long intervals, with the time-tables so arranged that only on rare occasions several trains start simultaneously, a higher efficiency may be aimed at.

Electric light engineers will look with amazement, and perhaps envy, upon the variations in the voltage marked on Figs. 2, 3, and 4; but these are exceptionally great fluctuations, and there are many electric tramways where the volts do not vary more than 15 per cent. A sudden call for large currents always lowers the potential, and this is partly due to the feeders being proportioned to the average output, and partly to the momentary slowing down of the engine. When the governor begins to act, the excess load has very often already disappeared, and then there is a tendency to racing for the next moment, and a simultaneous rise of E.M.F. above the normal. At the City and South London Electric Railway, which is only 3¼ miles in length, the deflections on the voltmeter vary between 370 and 500, notwithstanding compound-wound generators, and a regular schedule time of running the trains. Several years ago I suggested a remedy for equalising, to some extent, the load upon the generating plant of an electric tramway with overhead conductors; but my sugges-

* Paper read March 24, 1892, before the Institution of Electrical Engineers.

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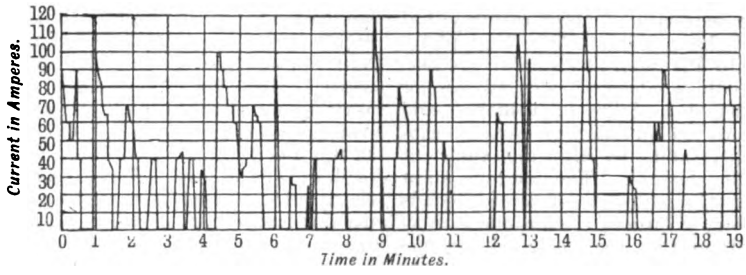

FIG. 1.—Accumulator Car. Rate, 6 miles per hour. 1·086 H.P.H. per car mile.

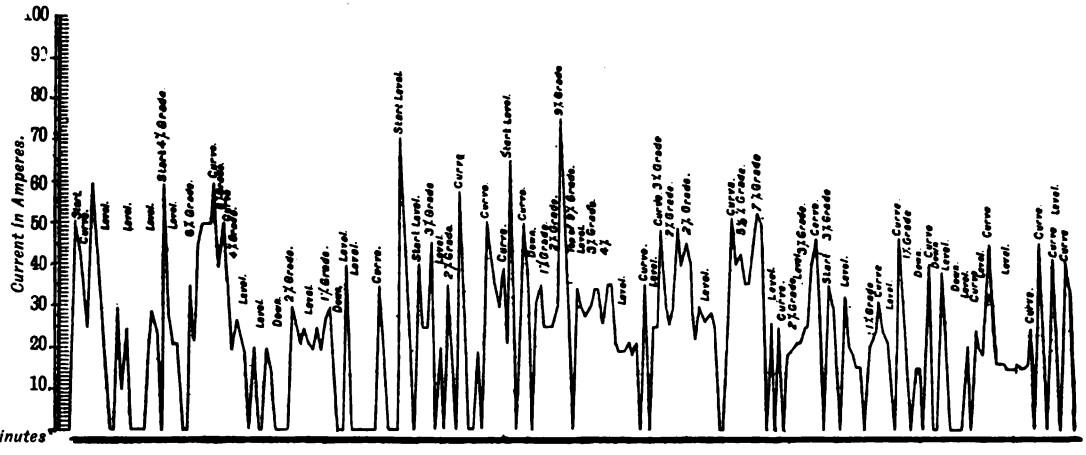

FIG. 2.—Diagram showing Current Readings taken on a street railway car equipped with 2-15 H.P. Thomson-Houston motors. Rate 20 miles an hour. 13·6 H.P.H. average for trip. Average E.M.F., 452·3 volts; maximum, 520; minimum, 360. Average current, 22·4 amp.; maximum, 75; minimum, 0. Test made at Des Moines, Iowa, April 21, 1891, over 20 miles of road.

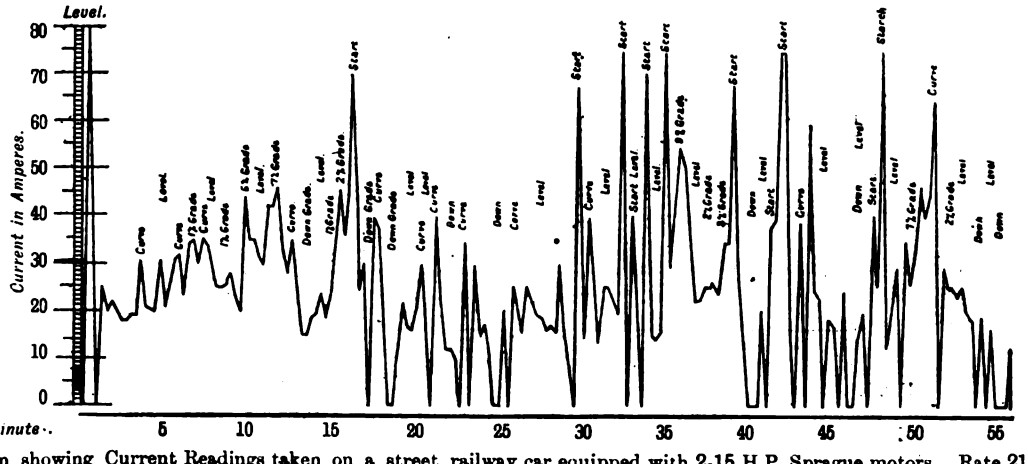

FIG. 3.—Diagram showing Current Readings taken on a street railway car equipped with 2-15 H.P. Sprague motors. Rate 21·82 miles an hour. 14·46 H P.H. average for trip. Average E.M.F., 454·1 volts; maximum, 560; minimum, 320. Average current, 25·95 amp.; maximum, 75; minimum, 0. Maximum H.P., 45·8; minimum, 0. April 21, 1891, over 20 miles of road.

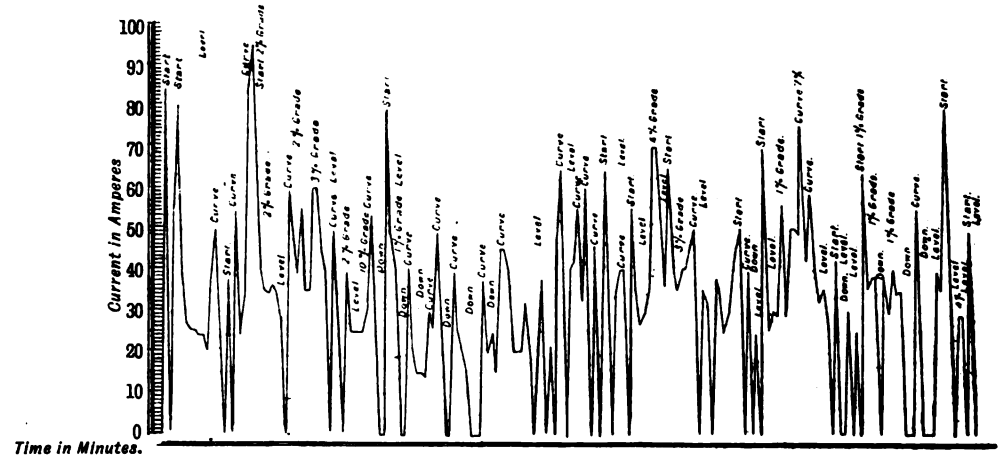

FIG. 4.—Diagram of Current Readings taken on a street railway car equipped with 2-15 H.P. Westinghouse motors. Rate 24·49 miles an hour. 15·49 H.P.H. average for trip. Average E.M.F., 444·8 volts; maximum, 560; minimum, 380. Average current, 31·3 amp.; maximum, 95; minimum, 0. Test made at Des Moines, Iowa, April 21, 1891, over 20 miles of road.

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tion has not been adopted. I advised the use of secondary batteries to act as regulators—not batteries of large capacity, but such as would give a very high discharge rate. Plain lead plates of very large surface, formed on the Planté or any similar process, would certainly add to the smooth working of any railway or tramway where great fluctuations of load are unavoidable, and compound winding insufficient. An accumulator of this description could be made very cheaply, and, by allowing sufficient material, it can be of any durability desired. The diagrams show that the large excess of current is only required for a few seconds at a time; therefore a storage battery of large surface would furnish this in a far more rational way than the best designed dynamo worked by the most delicately governed steam engine. It would save engine power. and reduce the chances of breakdowns due to sudden shocks to the generating plant.

Again reverting to our diagrams, which, to the practised eye, reveal a number of interesting points, we find that, on starting a single car, from 20 to 50 E.H.P are absorbed, and this occurs just when the motor is giving a comparatively small mechanical power at its minimum efficiency; this energy is absorbed in producing the initial statical pull, which must be created by many ampere turns. Now, in order to get many ampere turns without excessive currents, I designed, some eight years ago, a switch which throws the motors in series when starting, and in parallel (when two or more motors are used) when a sufficient counter E.M.F. is created by virtue of a certain speed. I also subdivided the field-magnet coils, in order to obtain several graduations and regulate the fields to the requirements of the load and speed. Up to that time electric engineers used idle resistances for varying the speed and power. Mr. Sprague and others have adopted a similar method of regulation. The Thomson-Houston Company use resistance coils up to a certain point, after which portions of the divided field coils are thrown out of circuit. By a judicious arrangement of field windings to suit the exigencies of a given road, a very fair all-round motor efficiency can be obtained.

The battery car, from which diagram Fig. 1 was obtained, required for its propulsion 1·086 electrical H.P.H. per mile run, with an average load of 7 tons over a line having no gradient above 4 per cent. The figures obtained by Mr. O. Crosby on three American lines with overhead conductors accord with the above very closely. Thus, on the Richmond line the readings were 1·18 H.P.H. per car mile, at Cleveland 0·9, and at Scranton 0·94 H.P.H. These cars were very much lighter than the one driven by accumulators, but there is a gradient of 9 per cent. at Richmond, and one of 7 per cent. at Scranton, while the Cleveland line is tolerably level; the speeds at Cleveland averaged 9 miles per hour, and at the other two lines six miles per hour. The coal consumption measured at the generating stations came out as follows:—For the Cleveland line, 8lb. per car mile; and at Scranton, 5·6lb.; that of Richmond could not be ascertained, as the same boilers were used for both the tram line and the electric lighting plant.

On the Frankfort-Offenbach Tramway, and on the Mödling line, near Vienna, both built by Messrs. Siemens and Halske, the coal consumption varies between 7 and 8lb. per car mile. Unfortunately, I have not been able to ascertain the evaporative quality of the coals used in these places. Mr. J. S. Badger, in a highly interesting recent communication, relates that the very best station performance he met with in the United States was 1 E.H.P. for 5lb. of slack coal evaporating 7½lb. of water. Writing on the consumption of fuel in general on a number of American tram lines, he found that it varied between 4·3lb. to 12·2lb. per car mile, according to the quality of fuel and the nature of the road and load. Many of the American tramways have recently adopted large cars up to 25ft. in length inside, whereas the usual standard type of car is only 16ft., carrying a proportionately smaller number of passengers, although I have frequently seen 70 passengers occupying a 16ft. car intended to seat 22 people. Overcrowding is not allowed on English tramways.

I have collected a very large amount of material with regard to the all-important question of operating expense, and I am greatly indebted for information given by Mr. Alexander Siemens, Dr. E. Hopkinson, Mr. Holroyd Smith, the Allgemeine Elektricitäts-Gesellschaft, Mr. J. S. Badger, and Mr. Robert W. Blackwell. Full tabulated statements are appended: to read the same would occupy more time than is at our disposal; moreover, it would add to the monotony of an already very dry paper. With your permission, I will only make such observations regarding each table as may render some assistance to the study of them. Due regard should be taken, in each of the lines, to local conditions. In Germany, for instance, the wages, which form the principal item in the operating costs, are about one-half those paid in the United States. Wages and salaries in England take an intermediate position. Again, the cost of fuel varies in almost every city in the world.

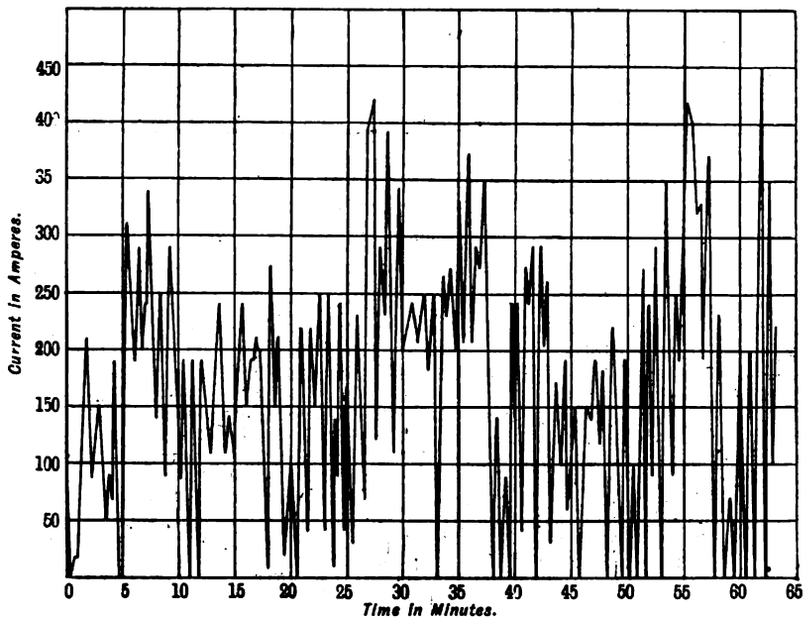

Fig. 5.—Roundhay Electric Tramway, Leeds. Ampere Readings at Generating Station, with five cars on the road. Mean E.M.F., 280 volts.

One of the oldest electric tramways in the world is that of Frankfort and Offenbach, in Germany. It was built by Messrs. Siemens and Halske, and opened to the public in April, 1884. Table I. shows the detailed working expenses for the year 1890, giving the sum of 4·608 pence per car mile, including all charges. The first financial year—1884-85—gave a much higher figure, namely, 8·256 pence per car mile; and it is interesting to note that the working expenses were reduced year after year: this was largely due to improved appliances and the consequent reduction in the maintenance items, as well as in wages. The expenses of the other tramways in the city of Frankfort (which are worked

Table I.—The Frankfort-Offenbach Electric Tramways.

Working Expenses of the Year 1890.

	Pence.
Fuel, per car mile	0·48
Wages of drivers and conductors	0·864
Salaries and wages at the generating station	0·96
Maintenance of machinery	0·576
„ „ line and buildings	0·288
Taxes and municipal charges	0·058
Miscellaneous	0·518
Depreciation account	0·864
Total per car mile	4·60

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with horses) for the year 1890 amounted to 9·022 pence per car mile, or nearly double that of the electric line. The slotted-tube overhead-conductor system is used here, and the entire rolling stock consists of only 14 cars—10 of which are fitted with electric motors, serving as tow cars—holding 24 passengers each. About 1,050,000 passengers are carried per annum; this is considered a very low figure, and is partly due to the competition of a local railway. In consequence of this small traffic, the ratio between expenditure and revenue is as high as 70 per cent., notwithstanding the moderate traction costs.

A more recent and equally interesting example of electric tramway enterprise in Germany is that of the city of Halle. The cars on this line were originally drawn by horses, but a year ago the municipal authorities gave permission to the Allgemeine Elektricitäts-Gesellschaft to erect overhead conductors on the plan adopted by Mr. Sprague in America. I am indebted to Mr. Emil Rathenau for a detailed statement of working expenses ranging over six months—from July 1st until the end of December, 1891. Table II. gives the averages per month and per car mile. The general expenses include taxes, municipal charges, and water-rates. The water is obtained from the town supply, the sinking of a well having been found impracticable. The rolling stock consists of 25 cars; the average number actually running was 20·55. They carry drivers, but no conductors, and this fact renders the wages account remarkably low, the entire working expenses coming to only 2·624 pence per car mile, or 54 5 per cent. of the gross revenue. It must be observed, however, that no allowance has been made for depreciation, which, if included, would add nearly another penny per car mile to the expenses account. Incidentally it may here be mentioned that the Imperial German Government stopped the running of the electric cars immediately after the opening ceremony because they interfered with the proper working of the telegraphs and telephones. The case came before the law courts, when the judges decided in favour of the tramway company, stating at the same time that the streets of a city were intended for general traffic, that their course could not be altered, but that the postal authorities could easily arrange the telegraph and telephone wires so that they should not be influenced by the electric lines, which use the rails and earth for the return circuit. The alterations were made, and the tramway has had a good time ever since.

The most remarkable of European electric tramways is that of Budapest, which was constructed by Messrs. Siemens and Halske, of Berlin. A few months ago I visited the Hungarian capital, and I was delighted with the perfect working of the electric cars. Underground conductors are used in this case, and the conduit is immediately underneath one of the tram rails, so that there is no additional slot in the roadway. About 50 electric cars are now in operation over 20 miles of track. The system is exceedingly popular, and it carries a larger number of passengers per mile than the horse tramways. This is probably due to the greater speed, the electric cars being allowed to run 11 miles per hour in some of the streets. I have not been able to obtain detailed working expenses, but I have been informed that the same never exceeded 50 per cent. of the revenue since the opening of the line two years ago. The ratio of working expenses and revenue on the horse-car lines at Budapest is 72 per cent.

Another among the numerous Continental electric tramways is that running between Florence and Fiesole, a distance of 4·5 miles, which was the first continuous steep-grade electric line in Europe. The Sprague system is used in this case. Table IV. is prepared from data contained in a recent Paper by Mr. C. P. Sheibner, of the Institution of Civil Engineers. The author of this interesting Paper gives, under the heading "Motive Power," the sum of the expenses arising through wages at the generating station, wages of car drivers, fuel, water, repairs, &c. These I have divided in my table in order to facilitate references with data obtained from other lines. It would be an excellent thing if all the electric tramways would keep a uniform record of all the details of working expenses, in the manner done by the existing horse tramways under the Board of Trade rules.

Coming now to electric traction enterprises in the United Kingdom, we find, in Table III., referring to the Blackpool Tramway, that the gross expenses amounted last year to 9·91 pence per car mile, or 57·8 per cent. of the gross receipts. This is a most satisfactory result, considering that the winter traffic of this seaside resort is only just sufficient to cover operating costs, and all the profits have to be earned during the holiday seasons. This is the only line in England, and the oldest line in the world, worked with underground conductors in a slotted conduit. The rent charged by the Blackpool Corporation for the use of the line forms a considerable item—1·773 pence per car mile—in the sum of the working expenses. Directors' fees and secretarial charges also seem to be liberally arranged, making 1·187 pence per mile.

On the Bessbrook-Newry Tramway, where water-power is used for driving the generators, the haulage costs during six months ended December 31, 1890, amounted to 3·97 pence per train mile. This includes water rent, rental of buildings; wages of driver, guard, and dynamo attendant; maintenance and repairs to dynamos and conductor; oil, tallow, and waste. During the period stated the train mileage was 10,400; the number of passengers, 50,800; and goods carried, 8,600 tons.

Table II.—The Halle Electric Tramways.

Working Expenses for Six Months ending December, 1891.

Average number of cars running	20·55
Total car miles for six months	266,796
Average number of car miles per month	44,466
" " " day	1,449·3
Daily average mileage for each day per car	70·6
Total gross receipts for six months	£5,354. 8s.
Average gross receipts per month	£892. 8s.

Working Expenses.	Pence.
Coals	0·3980
Waste, oil, and cleaning materials	0·1444
Wages and salaries	1·4430
General expenses	0·3930
Life insurances	0·0216
Maintenance of track and overhead conductors	0·0459
" buildings	0·0036
" boilers and machinery	0·0120
" cars	0·1480
" workshops	0·0148
Total working expenses per car mile	2·6243

Table III.—Blackpool Electric Tramway.

Working Expenses for 1891.

Total number of car miles for one year	98,000
Average car miles per month	8,166·6
Gross receipts for one year	£7,241

	Per car mile. Pence.
Repairing centre channel	0·345
" roadway	0·452
Rent, at 6½ per cent. of cost of line, to Corporation	1·773
Repairs of armatures, fittings	0·461
Decorating and plumber's work	0·189
Fire and boiler insurance	0·019
Ground rent	0·125
Wages of drivers, conductors, engineer, ticket clerk, &c.	3·260
Coal, oil, waste, &c.	0·714
Water and gas	0·223
Rates and income-tax	0·874
Printing and stationery	0·076
Salaries of directors, secretary, auditors, and clerks	1·187
Compensation for damages	0·016
Miscellaneous	0·197
Total working expenses per car mile	9·911
Ratio of operating expenses	57·8%

Table IV.—The Florence and Fiesole Electric Railway.

Working Expenditure, based on an Average of 600 Car Kilometres, or 375 Car Miles, per day.

	Per car mile. Pence.
Traffic—	
11 guards and 3 inspectors	0·960
Maintenance—	
Inspector, foreman, and 8 men	0·680
Motive Power—	
Wages at generating station	0·386
10 car drivers	0·898
Fuel, 1 ton per day, at £1 12s. per ton	1·003
Water, oil, repairs, and sundries	0·513
Depreciation and Renewals—	
Boilers, 7 per cent.; electric plant, 8 per cent.; cars, 5 per cent.; line, 1 per cent	2·080
General Charges—	
Rates and taxes, office, and administration	1·050
Total per car mile	7·570

(To be continued.)

Institution of Electrical Engineers.—At a students' meeting held at the Library of the Institution on Friday, the 25th ult., Mr. A. T. Snell presiding, Mr. C. A. Gawthorp read a Paper on "Measurements of Power in Alternate-Current Circuits." At the next meeting, April 8th, Mr. Parr will read a Paper on "Absorption and Transmission Dynamometers."

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LEGAL INTELLIGENCE.

Lane Fox v. Kensington and Knightsbridge Electric Lighting Company (Limited).

WEDNESDAY, MARCH 30TH, 1892.

JUDGMENT.

Mr. JUSTICE SMITH: This is an action brought by Mr. St. George Lane Fox, an electrician of high repute, to test the validity of a patent taken out by him on October 9, 1878. The plaintiff alleges that he then hit upon the idea that by utilising secondary batteries as invented by Planté, and coupling them up to the mains which conveyed the E.M.F. in his system of distribution of electricity, such force could be kept constant in the mains, and then an even steady light would be had in incandescent lamps which otherwise would not be. The Attorney-General designated this invention as being one to keep a constant potential at the lamps with a variable load. It has been proved the system of distribution of electric current for incandescent lighting in conjunction with the use of secondary batteries by reservoirs was a novel and valuable suggestion, which has aided the perfecting of that science which has culminated in the incandescent lighting of the present day; and it certainly appears to me that if the plaintiff did invent and carry to a practical result what is now claimed for him, he is an inventor of very great merit. Some ten years prior to the year 1878 Gaston Planté had invented and brought into use what is known as a "secondary battery," that is, a reservoir in which the electric current emanating from a generator could be stored. Daniell, my brother Grove, and Smee had also invented cells to act as accumulators of electrical energy; and these were in common use in telegraphy and other electrical work. The use of switches was also well known. They were means by which an electric current could be turned on or off, whether into or out of an accumulator, or in any other circumstances in which it was desired to turn on or off the electric current. Prof. Forbes told me the switches were as commonly used in electricity as water taps in the distribution of water. This secondary battery of Planté consists of a number of cells joined together, each cell holding sulphuric acid, in which are immersed plates of lead rendered porous and oxidised by a process fully described by him. These secondary batteries had, before 1878, been used for the storage of electric energy, and utilised, among other things, for the purpose of ringing bells or kindling lights, the energy then wanted being let out of the secondary battery by the pressure of a button, as is well known to many. Prior to 1878, attempts had been made at lighting by electricity, the means adopted being to place arc lamps into what is called series, that is, into line, and to pass the electric current through each lamp, and thence to what is known as earth. This system, though suitable to the lighting of lamps in streets, and such like, was not adapted to the lighting of the interior of houses and other buildings, as is now done by incandescent lighting; and, to use the words of Sir Frederick Bramwell, a Director of the defendant Company, "the great question of the day was the distribution of electric light." In this state of circumstances the plaintiff took out his patent of October 9, 1878. In it, among other things, he sought to bring about a distribution of the electric current, or, in other words, to divide the main current into a number of small currents, branching off from the main current, and again branching off from them, so that by placing his lamps into what is called parallel, that is, at the side of the main current, instead of in a line with it, each lamp might be fed by a small current, which, when it had performed its mission at the lamps, and exhausted its energy, or, in technical language, had reached "zero potential," should pass on therefrom to earth. By this means of distribution of the electric current, and the other means stated in the specification, the plaintiff designed to light by incandescent lighting towns and other inhabited districts. The name the Attorney-General gave to the proposed system was "the multiple parallel incandescent bridge." The plaintiff, as before stated, for the purpose of carrying out his proposal, determined to couple up the secondary batteries of Planté to his system of distribution. The complete specification as it now stands, page 5, lines 42 to 44, states that "the purpose for so doing was to distribute and regulate the electric current for obtaining light by electricity." The plaintiff's case is that by coupling secondary batteries to the mains, the electric energy therein would flow from the mains into the batteries when the energy in the mains was above equilibrium, and also inflow from the batteries into the mains when the energy therein was below equilibrium, and that thus a constant potential would be kept in the mains, and the light in the lamps steady. The defendants, in the first place, assert that the specification shows that Planté batteries were resorted to by the plaintiffs, not for the purpose, as he now states, of regulating the electric current, but for the purpose of storing up what excess motive force might emanate from the generator when the load upon the main was light, or, in other words, when the lamps were off; and of using such stored up force when the load upon the mains became heavy—that is, when the lamps were on or when the generator was not at work. They say that the present claim of the plaintiff as to using secondary batteries for regulating the electric current is not to be found in the complete specification as it originally stood, and then it is only rendered possible by an adroit amendment made therein in the year 1883, when the second disclaimer took place. It becomes necessary to see what the complete specification did contain when filed on April 9, 1879. The Attorney-General, in opening the case, and again at the end of his reply, told me that if Mr. Lane Fox had now, in the year 1892, to sit down and re-write a provisional and complete specification of his invention of 1878, with all his subsequent knowledge, he would write it again in the same words and the same form. This statement in reply somewhat stretched my credulity, seeing that he and Sir Horace Davey had occupied me for fifteen days in trying this case, a very considerable portion of which had been taken up in discussing what the two documents meant. By the complete specification Mr. Lane Fox claimed for improvements in electric lighting by, amongst others, the six following means:—First, by means of the distribution of electric energy by mains of branches and sub-branches; second, by means of this distribution in conjunction with incandescent lamps; third, by means of an apparatus for measuring electricity; fourth, by means of the employment of secondary batteries as reservoirs in combination with his system of distribution; fifth, by means of the use of a regulator and other mechanism wherewith to regulate the E.M.F. in the mains; sixth, by means of mechanism wherewith to convey electric energy. On the 26th January, 1882, the plaintiff disclaimed his claim to his appliances wherewith to measure and to convey electric energy; and on July 30, 1883, he further disclaimed his claim to his distribution of the electric current, whether alone or in conjunction with the incandescent lamp, and also his claim to the regulation and other mechanism which I shall hereafter for the sake of brevity call the electrometer. It will be seen that all that was left of his patent, as the specification now stood, was his claim for distributing and regulating the electric current for obtaining light by electricity by means of the employment of secondary batteries as reservoirs of electricity in combination with a mode or system of distribution of electric energy. In the specification, after describing a lamp and the way of distributing the electric energy and the means for measuring it, the plaintiff makes this statement: "The E.M.F. of the electric conducting mains should be kept as nearly as possible constant at, say, 100 volts of British Association units of E.M.F." The Attorney-General in opening this case stated that this invention of 100 volts showed the foresight of Mr. Lane Fox, for it was the pressure now universally adopted. This, upon the evidence, appears not to be so, nor does there seem to be any special virtue at all in having a pressure of 100 volts. Dr. Hopkinson told me that at Paddington they are working a pressure of 130 volts; in the Law Courts a pressure of 85 volts; and in his own house he uses a pressure of 50 volts; but be this as it may, it has nothing to do with what I have to decide, as I stated during the progress of the case. Mr. Lane Fox then proceeds to deal with secondary batteries as follows, line 51, page 4, to line 6, page 5:—"A number of secondary batteries, such as Planté's (lead and sulphuric acid), such batteries being joined together in series between the main and the earth will serve as a kind of reservoir for the electricity. The cells should have a very large conducting surface, and there should be several batteries connected up at the various points of the mains, so that by increasing the E.M.F. during the hours when not much electricity is being used they will become charged, and the electric force will be stored up in them, so that a sufficient supply will be available when the E.M.F. falls owing to the draught from the mains when the force is most used and needed. The number of cells in each of these batteries will depend on the E.M.F. of the mains. Fig. 5* is a diagram representing a secondary battery joined up between the main and the earth for the purpose above described. E indicates earth, and L lamps." It is true that in the paragraph about secondary batteries Mr. Lane Fox does not mention anything about their being employed to keep the E.M.F. in the mains constant; but later on, at lines 14 to 16, page 5, he is explicit on the matter. He says: "In order to keep the E.M.F. in the electric mains constant, it is desirable to have, in the first place, several generating machines; also a number of reservoir batteries as before explained." He then goes on to disclose his electrometer, as follows:—"Next it is necessary to have some regulators such as that about to be described. In my regulator, I make use of what is known as the quadrant electrometer." He then describes the mechanism of the instrument, and finishes: "The E.M.F. can be regulated either in this manner or by otherwise effecting the action of the electric generators through the instrumentality of the currents set up by the pegs above described, so as to increase or diminish the action of the generator." It was known to electricians at that time that by reason of the resistance of the mains the farther the electric currents travelled up them from the dynamo, the less was the potential in that current, or, in other words, that by reason of the resistance of the mains the farther the lamps upon circuit were situated from the dynamos the less illuminating power they received. This, upon a long circuit, was matter of moment. Anxious as I am to read the specification in favour of the patentee, I cannot do so without seeing that Mr. Lane Fox, when he drafted it in April, 1879, had in his mind as regards the matter now in hand, two separate and distinct ideas. The one was that, by coupling up secondary batteries to his system of distribution of electric current, he might be able to neutralise the pressure of the mains, and thus render constant the E.M.F. therein (this would be in aid of the dynamo, as Prof. Perry stated). The other was to regulate such E.M.F. in the mains (and this, as it seems to me, was for the benefit of the lamp). These ideas are separate and distinct. Prof. Forbes stated, if it be evidence (which I think it is not), that his reading of the specification was that Mr. Lane Fox meant a constancy of pressure all over, and at all times; and Mr. Lane Fox, in cross-examination upon his lecture delivered at the Royal Institution in 1832, stated to the same effect. In my judgment the defendants are not correct when they state that Mr. Lane Fox, by this specification, only claimed the use of secondary batteries as reservoirs, for by these batteries he also claimed to keep the E.M.F. in the mains constant. I am against the defendants upon this point. The defendants, however, say that if the specification is to be read as I read it, the patent is bad, because the complete specification, as it now stands, is not in conformity with the provisional. This point appears to me to be a formidable one for the plaintiff. It is unnecessary to go over the earlier cases cited by counsel on either side, for they are dealt with in the late case in the Court of Appeal of *Nuttall* v. *Hargreave* ("First Chancery Division, 1892," page 23). The law is clear. It is this. A patentee must describe the nature of his invention in his provisional specification; he need not go into details, but he must describe, as I have said, the nature of his invention. In his complete specification, when going into detail, he must describe the

* See *The Electrician*, Feb. 26, 1892, p. 438.

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same invention—if not, the patent is bad. Now, what has Mr. Lane Fox done here? In his provisional specification he states, "The E.M.F. for the electric conducting mains should be kept as nearly as possible constant, at say, 100 volts, or British Association units of E.M F. A number of Planté's (lead and sulphuric acid) cells joined together in series between the main and the earth will serve as a kind of reservoir for the electricity. In order to keep the E.M.F. in the electric mains constant it is desirable to have, in the first place, several generating machines." It must be noted that he does not here state that secondary batteries are available for this constancy, as in his complete specification he does, but proposes that the generators should keep the E.M.F. constant, and not even in conjunction with the secondary batteries. He then goes on to state that it is necessary to have the electrometer for the purpose of regulating the E.M.F This provisional specification, reading it most favourably for the plaintiff, can only be read to claim for the invention of using secondary baateries, the keeping of the E.M.F. constant. I have no doubt that in the complete specification, as originally filed in April, 1879, the words "regulating the electric current," at page 3, line 16, and at page 5, line 44, were solely applied to the electrometer. What has been done is this: Upon disclaiming the electrometer on July 30, 1883, four years after the complete specification, it was sought to apply the words "regulating the electric current," which had been theretofore applicable solely to the electrometer to secondary batteries, so as to claim for them not only the power of keeping the force constant in the mains, but of regulating it therein. The question is, does the plaintiff now claim for the same invention in his complete specification as it stands as he did in his provisional specification? I say he does not. In the provisional specification he claimed as his invention the use of secondary batteries in aid of the dynamo to keep the E.M.F. in the mains constant; whereas he now by his amendment of his complete specification claims as his invention the use of secondary batteries, not only to keep the E.M.F. constant in the mains in aid of the dynamo, but also to regulate the E.M.F. in the mains for the benefit of the lamps. The case is this: In the provisional specification he claimed by his use of secondary batteries, invention X in the Provisional Specification, he further claimed by his use of the electric meter, invention Y. In the complete specification he now claims by his use of the secondary batteries, inventions X + Y. How can it be said that he now claims in the complete specification the same invention as he did in the provisional, unless X and Y are the same invention, which, in my judgment, they are not, and what is more the evidence leads me to conclude that secondary batteries, when coupled up to a main, will under certain conditions bring about some of the regulating force originally claimed for the electrometer, but automatically will not bring about the constancy originally claimed for them. The eminent electricians called by the plaintiff in conjunction with those called by the defendants, have satisfied me that in some circumstances, especially when fully charged secondary batteries coupled to the plaintiff's system of distribution, have an inherent power of regulating the E.M.F. in the mains, but the amount and value of such power was matter of keen dispute. The evidence shows that the batteries, automatically worked, will not keep the E.M.F. in the mains constant. As to the power of regulation, Professor Perry, called by the plaintiff, stated that the compensating effect was a very important one, and that the advantage of the patent was to prevent flickering. The plaintiff declared this invention was a departure from many of the things written before 1878; and as regards that part of his invention for distributing electric current, together with coupling of secondary batteries to mains, I think may be so. Professor Silvanus Thompson stated that with batteries so placed the regulating effect is a necessary consequence. Professor Barrett stated that secondary batteries, he knew, would operate to bring about a constant pressure; and Professor Forbes said that they had the regulating effect spoken of by the witnesses, and he added, "I have always considered secondary batteries most essential for steadiness of light," and went so far as to say that he had never seen a steady light without secondary batteries. He then alluded to the lights of the Court in which I was sitting, and for which no secondary batteries are used, and told me that the lights were varying from 15 to 20 volts In my judgment, if this were so, for all practical purposes the light was an even and steady one, and as good as could be desired. The witnesses called for the defendants did not deny that secondary batteries had some regulating effect. Sir Frederick Bramwell said, "I think they may be acting as regulators in part. I think the batteries would help to maintain the constant pressure at the mains. I think the secondary batteries would tend largely to correct the rise and fall of voltage when lamps were turned on and off, the batteries would maintain or tend to maintain a constant E.M.F. at the lamps." He also stated that they could not be used automatically. Dr. Hopkinson upon this point stated:—"Secondary batteries will always diminish the flicker, if there were a flicker; they would have exactly the same effect with a steam-engine as with a gas-engine. If the batteries were taken away there would be absolutely no difference upon the pressure in the mains. There are scores of stations without batteries." Mr. Crompton stated that secondary batteries with switches remaining constant did not tend at all to diminish flicker. Mr. Miller, the resident engineer at Kensington Court station—that is, the defendants' station—stated that secondary batteries do not automatically regulate the potential, although he said in cross-examination if there be a change of pressure in the mains the secondary battery minimises the effect. Mr. Swinburne declared you could not use secondary batteries for storage so as to be of use against flickering. Mr. Kennedy, the civil engineer, who had made tests wholly unconnected with this action, produced them to explain the extent of regulating a secondary battery was capable of, and he stated that a secondary battery will help in regulating small variations, and he adds, "For very small variations such as continually occur in a circuit with many lamps, the secondary battery will help to steady the lights, they do not keep the pressure constant." Mr. Drake, who had been working practically at batteries since 1884, and has had hundreds of batteries under his charge, and who was, to my mind, a peculiarly intelligent witness, stated, "There is a prevention of flicker by use of secondary batteries if fully charged, even though the motive force be a steam engine and dynamo, that is, if the actions are very quick. If a few lamps are shut off in a small system so that the shutting off of a few lamps affects the light, the secondary batteries would help to regulate, but only for a few moments," and Mr. King, who had had great practical experience in manufacturing secondary batteries since 1883, and had made upwards of 38,000 experiments in charging and discharging them stated in cross examination, "I will swear there would be more variation (that is in the voltage in the mains) with secondary batteries than without them. I say the secondary batteries, the current running constant, tend to cause a variation rather than diminish it." It was proved that many installations were worked without the application of secondary batteries at all, the Law Courts being amongst the number; and, as before stated, Dr. Hopkinson deposed to scores of stations existing without secondary batteries. It is true that secondary batteries are extensively used, though obviously by no means universally. Mr. Drake told me that he was connected with about 250 installations of incandescent lighting, of which about one-third had no secondary batteries, and the other two-thirds had. He also stated, and I have no reason to doubt him, that the object of using secondary batteries was to serve as reservoirs to enable the engine to be stopped, and yet to have the incandescent lighting continued from the motive force stored up in the batteries. In cross-examination he said that he had some batteries on with the dynamos going, but that he charged them by day and worked them off by night. Sir Frederick Bramwell, Mr. Crompton, and others, gave strong evidence that the principal use of secondary batteries was as reservoirs, and this appears to me to be the case. Scientific evidence was given to show what was the real rise and fall of voltage in the batteries and mains upon the application or withdrawal of the E.M.F. therefrom. This evidence was illustrated by diagrams which it is impossible to reproduce here even if it were desired to do so. In my judgment the plaintiff as to the controlling effect of secondary batteries has placed his case too high, and that the real truth is that if there be a short quick flicker at a lamp, a secondary battery coupled up with the main will at times help to diminish it; but the secondary batteries, as designed to be used by the plaintiff, that is, without mechanical and manual devices, will not bring about that constancy of pressure which the plaintiff claimed for them in his original specification. The result of the evidence upon this head I may, I think, accurately sum up in the words of an article in the *Engineer* newspaper of December 26, 1890, which the Attorney-General used largely in cross-examination of the defendants' witnesses. Mr. Crompton, Mr. Miller, and Mr. Kennedy said that the words were fairly accurate. They are as follows:—"One of the advantages found by having more than one pair of batteries attached to the system at points totally wide apart is, that the effect of the regulating movement of switching in an extra cell which would show a difference of two volts on the lamp is partly neutralised by the distant battery." Mr. Lane Fox, in his declaration made in March, 1883, stated that the effect of the change of about one volt upon a lamp was practically nothing; and if Prof. Forbes was correct in stating that there was a change of from 15 to 20 volts in my Court, it is obvious that a two-volt change is of little importance. The Board of Trade sanctions a change of 4 volts up and 4 volts down. In my opinion, the point taken by the defendants is fatal to the plaintiff's case, and that the complete specification as it now stands does not claim the same invention as the provisional.

I might stop here, but, as others may not agree with me, I shall give judgment also upon some of the other points raised. The next question which I take is that the plaintiff has claimed as an essential part of his system of distribution a return by the soil of the earth and which the defendants say is impracticable; the part of the specification which deals with this is as follows: "The way in which I distribute the electric energy so as to work a number of these lamps from a single source of electricity is represented in the diagrams Figs. 3 and 5, and is as follows: from one pole or electrode of the electric generator or generators situate at "A" (Fig. 3) proceed one or more large conductors from which branch out at various points where lights are desired smaller conductors which again may have conductors branching off from them, and so on. The other pole or electrode of each electric generator is connected with the earth, so that the conductor and its branches and sub-branches will be perpetually in a state of electric tension, tending to develop currents in every direction to the earth. One pole of the electric lamp is connected with the earth "E," and this may be conveniently effected by means of gas or water pipes when such exist, so that whenever the circuit is complete between the lamp and any of these branches a current of electricity will pass through the thin strip or wire, rendering it incandescent and so produce light." It was clearly proved that as regards the effective distribution of the electric current either of the three well known return conductors if practicable would be equally efficient, the three being the soil of the earth, an insulated or an uninsulated metallic conductor. It was also clearly proved that the plaintiff's system of distribution of the electric current ended at the positive pole of each lamp. The defendants assert that the plaintiff claims as part of his system of distribution a return by the soil of the earth; and secondly, that if he has not claimed the soil of the earth as the sole return conductor, still, he has claimed it as being one amongst others to be used, and that as the soil of the earth cannot be used for the purpose claimed, it makes the specification bad; and they cite *Simpson* v. *Holliday* ("English and Irish Appeal Cases," (page 315), in support of that proposition. An enormous amount of evidence was given as to what technical meaning was or was not to be attached to the words "earth," or "the earth." I am not going to review it, and the following are the conclusions I have arrived at. It was established that the word "earth" in a specification without a controlling context would have indicated to an electrician in 1878 that any of the then well-known return conductors, that is the soil of the

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earth, an insulated or an uninsulated metallic conductor, might be used. It was also proved that the like might be said of the words "the earth." It is true that at times the word "earth" is used in this specification; but when it is used in that part of the specification which specifically deals with the mode of distribution of the electric current, it is always "the earth." "The other pole of the electric generator is connected with the earth." "The conductor, &c., will be perpetually in a state of electric tension, tending to develop currents in every direction to the earth." "One pole of the electric lamp is connected with the earth, and this may be conveniently effected by means of gas or water pipes." It is common ground that the way a return current is connected with the soil of the earth is by what are called earth-plates, that is, a metallic plate or plates by which a good connection with the soil is attained for the return current. The way I read these last lines is, "One pole of the electric lamp is connected with the earth, which connection (I put in those words) may be conveniently effected by means of gas and water pipes;" or, in other words, the gas and water pipes are to act as earth plates. If the return connection has to be by a return other than the soil of the earth, as now suggested by the plaintiff, the stipulation for a connection with the earth by way of earth-plates would be meaningless, for no such provision would be required. I have no doubt that the words "the earth," read as they must be in connection with the context, mean the soil of the earth, and that alone. It is further argued by the defendants that the plaintiff must be taken to claim a return by the soil of the earth as essential to his invention because of the well-known expense attending the other returns in the case of lighting by electricity. Sir Frederick Bramwell has stated that out of a capital of £135,000 or £140,000, his Company has had to pay, for its return conductors alone, no less than £35,000 or £40,000. Other witnesses spoke to the great cost of metallic returns for lighting by electricity. I may point out that Prof. Perry, when pressed in cross-examination as to the meaning of the words "the earth," stated, "I have no doubt he (the plaintiff) intended to use the earth as a return conductor, that is, the earth as it exists." Prof. Perry was correct when he gave that answer. This being my reading of the term "the earth" in this specification, I have to inquire whether a return by the soil of the earth in a system of incandescent electric lighting such as designed by the plaintiff, could be worked. The evidence as to this is in reality all one way. One or two of the plaintiff's witnesses did at first make an effort to support the theory that it could be used, though not one single instance of the soil of the earth being used in the case of incandescent lighting as a return conductor was or could be produced. Dr. Hopkinson told me that the soil of the earth could only be worked on a very small scale, and could not be practically worked upon a system such as is represented by Mr. Lane Fox. Sir Frederick Bramwell also stated that a return by soil was not practicable for incandescent electric lighting, by reason of the large number of amperes that have to be dealt with, and that he had never known a return by soil successfully used in electric lighting. It is true that in telegraphy the soil is an effective return, but in such case the return current may be measured by a very small fraction of an ampere; whereas, to supply even the 328 lamps shown upon Mr. Lane Fox's Figure 3, and which represents only part of a larger system, it would require at least 125 amperes. In my opinion, it is not practicable in Mr. Lane Fox's system to obtain or use earth plates of sufficient size so as to make an efficient connection with the earth, on account of the magnitude of the current which would have to be provided for; and, even if it were, such a voltage would have to be used to get through the earth plate as to be out of all reason. In my judgment, a return by the soil of the earth has been proved to be unpracticable for the plaintiff's system. But although this is so, should I hold that the plaintiff claims a return conductor by the soil of the earth as being an essential part of his system of distribution? for if not, the point will not avail the defendant. The Attorney-General has satisfied me that I should not, and for this reason. It is the fact, as stated by Mr. Swinburne, that in 1878 any electrician would know, that if he did not want to use the earth—that is, the soil—he could use any other return conductor. It was proved by Sir Frederick Bramwell that "when you got your current into the return wire all object of subdivision has ceased. What you want to distribute is the current with potential in it—that is, with the effective energy in it." "It does not matter one farthing," says Sir Frederick, "if the return is soil or an insulated or uninsulated conductor." "The unsuitability of a soil return is because of the magnitude of the currents you are dealing with." This coming from a witness of the defendants' is conclusive. So it appears to me to show that a return by the soil of the earth is not an essential part of the plaintiff's system of distribution of electric currents. I notice that in the specification Mr. Lane Fox has claimed for distributing the electric current by "earth," which would not necessarily mean in the context the soil; so also as regards the distribution in connection with his lamps. I hold that Mr. Lane Fox, as part of his system of distribution which terminated at the positive pole of the lamp, did not claim a return by the soil of earth as an essential part of his system of distribution; and I decide this point in his favour. The case of the *Electric Telegraph Company* v. *Brett*, ("10th Common Bench," page 838), is somewhat similar to the present case, and, as far as it is similar, it is an authority for what I hold. I now come to the question upon which evidence was adduced, partly of a highly technical and partly of a practical kind, the question being whether, if Mr. Lane Fox's specification were followed out (apart from the question of the earth, about which I have nothing more to say) it could be made to work; and, if so, whether sufficient information was therein given to enable the intelligent electrical workman of 1878 to make it work. I was surprised to hear the Attorney-General, in reply, suggest that the specification did not claim for the automatic action of the electric current between the mains and the batteries. For fifteen days I had laboured under the impression that the plaintiff's case was that he did, and upon referring to my notes there can be no possible doubt upon the subject. The Attorney-General, when opening the case, stated, "It is not saying too much to say, my lord, as skilled electricians will tell your lordship, that, remarkable as it may be, every system of modern successful electric lighting which proceeds from generators, dynamos, and which is absolutely maintained at a constant pressure—what I call automatically maintained, without other devices for keeping the current constant, is an exemplification of Mr. Lane Fox's discovery and system." Again, "The number of cells in each of these batteries will depend on the E.M.F. of the mains." "That means," says the Attorney-General, "that these secondary batteries are in the position described, 100 lamps are on, they do not require more than one-tenth of the current which is being generated, the rest of the current goes into the secondary batteries, night comes on and 2,000 lamps are on instead of 100; and, accordingly, then, all the current is required, both coming from the engine and coming from the secondary batteries, and the engine and the secondary batteries give off at a constant pressure of 100 volts the current required for the lamps." The case proceeded upon this assumption of automatic action, and hours were occupied in giving evidence and discussing as to what plate area in the cells was required to bring about this automatic action. It is true that switches were referred to, but they were mentioned as being possible improvements upon Mr. Lane Fox's patent, and having been in common use in 1878, it was said that an intelligent workman would use them if he found he needed them to aid the automatic action. Prof. Perry, the first witness in the case, when asked to describe the plaintiff's invention, stated, "When the engine which drives the dynamos goes a little too fast, so that the pressure in the main tends to be too great for the lamps, the battery stores the surplus supply of energy; when the dynamo goes too slowly, giving out too little energy, the battery unstores, helping the dynamo." He then made a sketch showing how it acted, and added, "the secondary battery is an automatic regulator, in fact." The plaintiff in chief also described his system in such terms as only to describe an automatic action, and during his cross-examination he said to me, "I say in the specification it is stated that as an increase or decrease of energy is wanted in the mains, it is given out or taken in automatically." This is the plaintiff's own definition of what his own specification would bring about, and Prof. Barrett said, "In my opinion, switches seem only a cheap way of doing what Mr. Lane Fox proposes to do without them, and that it is better without switches." The Attorney-General's suggestion in reply is not well founded. The defendants' case was, that secondary batteries, when coupled up to mains with lamps on circuit, could not be automatically charged so as to be of utility, because to charge a secondary battery in such a position, such a voltage or pressure would have to be used as would destroy the lamps on circuit, unless resort were had to a system of manual and mechanical appliances, in the form of extra cells and switches, to keep the voltage off the lamps when the batteries were being charged. It appears to me that in 1878 Mr. Lane Fox had not rightly ascertained the voltage required to efficiently charge a secondary battery when coupled up to a main, and that he was then under the impression that a very slight excess of voltage was necessary either to charge or discharge it. It is manifest that he laboured under this impression, at any rate, till as late as March 14, 1883, when he made a statutory declaration for use upon the application for his second disclaimer. In this he deposed as follows:—"I say that when the E.M.F. is increased during the hours when not much electricity is being used, as described on page 4, lines 56 and 57, the few lamps turned on during the day would not be far too bright and would not be liable to break for the reason that, as would be obvious to any electrician, the increase of E.M.F. for fully charging the batteries need be very slight, less than a volt, the effect of which upon the lamps would be practically nothing." Prof. Perry also stated that with a force "of 101 volts you can charge the cells to 100 volts, that the batteries will charge and discharge with less than 1½ per cent. difference, and the plaintiff also stated "that the voltage should be kept as near 100 volts as possible." The Attorney-General, upon the seventh day of the trial, still insisted that 101 volts would charge a battery with 100 volts. Prof. Forbes, called for the plaintiff, by no means adopted this view of the case, but stated, that he had some tests which would show that you could charge a secondary battery with 5 volts excess, but that it took 20 hours to do so, and he did not state to what point upon the curve he arrived at with that voltage. It has been demonstrated to me by a large body of evidence that this suggestion of being able to charge a secondary battery at anything like an excess of one volt is an error, and that it cannot be done. I will single out the evidence of Mr. King and Mr. Drake, the most practical of all the witnesses called before me, as regards the charging and discharging of secondary batteries when coupled up to mains. Mr. King stated: "With an excess outside the battery of one volt you would get into the battery a very small amount of anything; indeed, something quite inappreciable. I say that, in practice, you have to get to 105 volts before you get any current into your battery any moment, and at this, the amount would be exceedingly small." Mr. Drake satisfied me that an excess of one volt was useless, and my impression is that Mr. King is about right when he stated that 105 volts are required before anything of utility is done as regards commencing to charge a secondary battery. It has been made quite clear to me that it requires a considerable excess voltage to charge a secondary battery, the reason being that it is necessary to overcome not only the internal resistance of the battery, but also the E.M.F. generated by the chemicals therein, which resists the entry of the electric current. The excess of only one volt, in my judgment, is practically useless. It is this initial mistake of the plaintiff which, as it appears to me, has caused him to describe in his specification the automatic action between the batteries and the main; and I may here state, for reasons hereinafter appearing, that in my judgment automatic action with lamps on circuit is impracticable. The evidence upon the question of what excess voltage is required to charge a secondary battery on the main is very voluminous, but I think I may summarise it as follows. I take what has

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been called the "plateau" theory, and use for the purpose of explaining it, Prof. Ayrton's curves. Many other curves have been put in evidence, but for the purpose I have in hand Prof. Ayrton's will suffice. The first question is, to what point upon this curve must a secondary battery be charged so as to discharge with utility, by which I mean to discharge in such a way as to keep or tend to keep the E.M.F. in the mains constant when such force falls, owing to the draught upon the mains. The Attorney-General says up to point "B" on this curve* is the proper point. Mr. Finlay answers him, and says, if only up to "B" your plateau theory of the automatic discharge breaks down, for you then get next to no plateau at all upon the discharge; and in this Mr. Finlay appears to be correct, and this without taking into account the sudden drop to about 15 per cent. of what admittedly takes place when passing from the charging to the discharging of a battery. If the charging and discharging curves are examined, it will be seen that with the battery only charged to "B" on the charging curve, the whole of the plateau upon the discharging curve, namely, from "A" to "B" is lost, and a sharp decline at once begins, which obviously will not bring about the theory of constant pressure in the mains when a load is placed upon them. The evidence given leads me to the conclusion that to charge a secondary battery so that it should discharge as desired by Mr. Lane Fox, the battery must be charged at last up to "D." The uncontradicted evidence shows that to charge up to "D" requires a voltage of 120 volts, to charge up to "C" requires a voltage of 113 volts, and to charge up to "B" (the Attorney-General's limit) requires a voltage of 110 volts. I will, however, here assume for this part of the case that the Attorney-General is right, and that point "B" is the point to charge to, though I do not agree with him. There is no question that it takes a voltage of 110 volts to get there. Prof. Perry told me that 103 volts would not be a damage to the lamps, that 105 volts would destroy the lamp within a reasonable time, that if you had to go up to 110 volts it probably would break the lamps, it would smash every lamp very soon, that 125 volts would destroy a lamp under an hour, and that 150 volts would kill the lamp in a few seconds. The plaintiff put the limit at 105 to 106 volts. He said that for some time you might go up to 110 volts without danger to the lamps—it would not tend to diminish its life very much; but to 105 or 106 volts you could press without detriment to the lamps, and he added, but I think wrongly, and he disagreed with the Attorney-General's theory of charging to "B," that 105 or 106 volts would be amply sufficient to charge a secondary battery. Prof. Silvanus Thompson gave the following list to show the effect of high voltage upon a lamp:—If a pressure of 95 volts is used, the life of a 100-volt lamp is 3,595 hours; if a pressure of 96 volts is used, the life of a 100-volt lamp is 2,751 hours; if a pressure of 97 volts is used, the life of a 100-volt lamp is 2,135 hours; if a pressure of 98 volts is used, the life of a 100-volt lamp is 1,645 hours; if a pressure of 99 volts is used, the life of a 100-volt lamp is 1,275 hours; if a pressure of 100 volts is used, the life of a 100-volt lamp is 1,000 hours; if a pressure of 101 volts is used, the life of a 100-volt lamp is 735 hours; if a pressure of 102 volts is used, the life of a 100-volt lamp is 601 hours; if a pressure of 103 volts is used, the life of a 100-volt lamp is 477 hours; if a pressure of 104 volts is used, the life of a 100-volt lamp is 375 hours; if a pressure of 105 volts is used, the life of a 100-volt lamp is 284 hours. I arrive at the conclusion that 105 or 106 volts is, at any rate, the maximum pressure which can or ought, in practice, to be placed upon a 100-volt lamp. It will be seen that with 105 or 106 volts, point "B" upon Prof. Ayrton's curve is not arrived at, it requires 110 volts to get there; and this, according to the plaintiff's witness, Prof. Perry, would probably break the lamp —would smash every lamp very soon. It will be noticed that with a voltage of 105, Prof. Silvanus Thompson states that a lamp has only an existence of 248 hours. What a voltage of 110 would bring the lamp down to can well be surmised. Then how can it be successfully contended that without some contrivance to keep the pressure off the lamp when the batteries are being charged even to "B," the plaintiff's specification can be made to work? It cannot be, and from these facts alone I come to the conclusion that the defendants are correct in their contention. In these circumstances it is not necessary to go further and deal with the weighty evidence given, that, in practice, to keep the batteries "in health," as it is called, that is, capable of performing their proper functions, they must repeatedly be charged up to above "D," and, consequently, to a voltage of 125. This evidence, in my opinion, is correct. If this be so, it is, *à fortiori*, that secondary batteries cannot be efficiently charged excepting at a voltage which, according to the plaintiff's own witness, would destroy the lamps under an hour. It was then said on behalf of the plaintiffs, supposing this to be so, still, if the plaintiff's specification be followed, and the plate area in the cells be increased, so as to have "a very large conducting surface," the voltage could be reduced to such a dimension that the batteries with lamps on circuit could still be charged automatically. I cannot do better than cite from Prof. Barrett's evidence to show what difficulties the plaintiff was in when this proposition was put forward. In cross-examination by Sir Horace Davey, the following took place:—"(*Q.*) You have used the words 'sufficiently large,' 'very large,' will you condescend to particulars? (*A.*) I can only give you my own experience. I should say 'very large' means with reference to what was known and in common use at that day. I should say nothing but trials would show, probably the first trial would be successful. It is a matter of individual judgment. Say, five times as large. It depends upon the size of the mains and the current, the larger the current the larger should be the conducting surface." Sir Horace Davey then passed on to other matters, but the next morning proceeded as follows:—"(*Q.*) I was asking yesterday what very large cells meant. (*A.*) Very large conducting surface has a definite meaning, in addition to that which I gave. It obviously means that the cells should be relatively large with the installation so that by increasing the E.M.F. a sufficient supply wil be available when it falls owing to the draught in the main—that is, large enough to supply sufficient when the draught in the main is most needed." I own that neither this evidence of Prof. Barrett nor any other given on behalf of the plaintiff satisfies me that by increasing the plate area in the cells to any practicable degree the excess voltage above pointed out would be got rid of, and what is most remarkable is that no evidence was adduced to show that it had ever been attempted, that the suggested result had been produced in practice. There is another fact also, which, to my mind, is of the highest import, viz., that for the 13 years this patent has been running, with the exception of what Prof. Barrett described as a small installation in his laboratory used for lecturing and teaching purposes, not one single installation has been in actual work upon the automatic principle with success. The case of Lady Conyers' ball, in 1882, put forward as an instance of the plaintiff having been successful with his automatic system, is not, in my opinion, an instance at all, as I will presently show. In the plaintiff's installation in Paris in 1881, there was no secondary battery used. At the Crystal Palace installation in 1882 switches were used. About the installation at the Brush Company in 1882, in which at first secondary batteries were used without switches, the plaintiff stated as follows:—"There were no switches in the Brush Company at first, but they may have been put in. I think at first the light was found to be irregular. The batteries soon deteriorated and went wrong; it was then found desirable to put in switches." "It may have been that the Brush Company very soon afterwards put in switches to avoid the irregularity which existed. It may have been thought desirable that switches should be added." At the King of Roumania's Palace in 1883, the installation had a regulator on the steam valve, as also an arrangement for switches. At the installation at the Opera House in Vienna, in 1883, there was an elaborate design for switches, though it was said that these were used to produce scenic effects; and at the installation for the Drapers' Company there were also two switches. These were the instances produced by the plaintiff of the practical working of his invention, not a single one, as it appeared, worked automatically with success. At Lady Conyers' ball at Queen's Gate, in 1882, an installation of about 70 lights was put up under the superintendence of Mr. Lane Fox. It was erected for the single night, and was the first of its sort. It certainly was not a success, for the lamps all went out in the midst of the dancing; but I take it that this is to be accounted for by the fact, as stated by Mr. Lane Fox, that at one period of the evening a crowd got into the engine-room and caused a disconnection, which was afterwards put right. It is true that on this night secondary batteries were used without switches, but it is also true that these batteries were sent up to Queen's Gate from Mr. Sellon's fully charged, though, as Mr. Lane Fox says, some of the acid had fallen out on the way. Mr. Erskine told me that these secondary batteries were used because they had not a large enough engine, and that in the afternoon the lamps were not bright, and that, by bringing up the batteries and attaching those to the main, they got in the evening a good light by the extra power attained out of them, and that the voltage used was between 45 to 60 volts. Mr. Lane Fox states that the batteries, when coupled up to the mains, continued to be charged and discharged during the installation, but he made no investigation of this at the time, and I am by no means convinced that Mr. Lane Fox's belief as to the charging is accurate, In my judgment this installation cannot be taken as a practical test as to whether secondary batteries can be automatically charged with lamps on circuit as required by the specification. The small laboratory experiment by Mr. Barrett from 1886 downwards, is the sole installation which Mr. Lane Fox can find, during the 13 years his patent has been in existence, to bring before me as an instance of the practical working of his system. I cannot accept this as substantial proof of the practical working of the plaintiff's system, as I am invited to do by him. It is but a small laboratory installation, used solely for teaching purposes, to describe the system of incandescent lighting, to show the effect a battery will have upon the short quick oscillation of a gas engine, and used with one, two, or three lamps at a time, though there were 10 lamps in all upon the circuit. Prof. Perry told me, and I have no doubt truly, that in his laboratory he had found he could charge a secondary battery at an excess pressure of one volt, a fact which has been demonstrated beyond question cannot be performed in the actual practical working of mains with lamps on circuit. Prof. Barrett told me that his engine produced amperes considerably in excess of what was wanted at the lamps, that he runs with a current of 18 amperes, his lamps only requiring 10, and that his batteries were not used for helping the dynamos, for they were not wanted for that purpose. I cannot think that this one small laboratory case, under the circumstances, is sufficient to outweigh the other cogent evidence given upon this head. Prof. Silvanus Thompson, upon cross-examination, stated that he had not in his experience known of a system of secondary batteries put up without switches. I am alive to the point made by the Attorney-General that if plaintiff's invention could be made to work so as to be of practical utility, it was none the less a good invention because improvements therein were subsequently made, and I agree with his law as to this. The question is could the plaintiff's invention, as described in his specification be made to work in practice? In my judgment, for the reasons above, it could not, and that ground is also sufficient to defeat the plaintiff's patent. I now come to the last point upon which I purpose to deliver judgment in detail, and that is, supposing the specification could be made to work so as to carry out the plaintiff's invention, was sufficient information given therein to the intelligent electrical workman of 1878? I must here observe, as has been often done before, upon the difficulty the Court is in in being called upon to ascertain the state of knowledge existing at the date of the specification, and more particularly is this so in the present case, considering the length of time which the plaintiff, for some unexplained reason, has allowed to elapse before bringing the validity of his patent to the test. The law as regards the sufficiency of description in a specification is as follows:—The specification may call upon a workman to exercise all the

* See *The Electrician*, Mar. 4, 1892, p. 466.

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actual existing knowledge common to the trade: but it must not call upon him to exercise his ingenuity or invention, see per Alderson, Baron, in *Morgan* v. *Seaward* (2 "Meeson and Welsby," page 544); nor cast upon the public the expense and labour of experiment and trial, per Abbott, Chief Justice, in *Rex* v. *Wheeler* (2 "Barnewall and Alderson," page 345); per Lord Abinger, in *Macnamara* v. *Hulse* ("Carrington and Marsden," page 471); per Pollock, Chief Baron, in *Stevens* v. *Keating* (2 Exchequer, page 772); and to use the words of Sir George Jessel, in *Plimpton* v. *Malcolmson* (3 Chancery Division, page 531), taken from those of Baron Alderson, it must not "take the form of a problem." It is said that the workmen of 1878 would have known two things: first, of what size the "very large conducting surface of the plates in the cells" should consist, so as to get rid of the excess voltage; and, secondly, that he would have known if he could not make the system work that he could apply extra cells and switches, so as to be able to cut the cells out from the circuit when the batteries were being charged. The evidence as to this is in conflict. The four Professors called by the plaintiff assert that there was plenty of information given in the specification, whilst the evidence for the defendants was to the contrary. As regards the state of knowledge in 1878, it must be remembered that this was the year of birth of electric incandescent lighting; and, indeed, in the next year it would appear that but little was known about it, for in 1879 a Parliamentary inquiry was held as to the practicability of electric incandescent lighting, at which some of the greatest electricians of the day gave evidence, amongst them Sir William Thomson, Sir William Siemens, and Dr. Hopkinson; and it would seem that they were by no means agreed as to its feasibility. I ask myself what would an intelligent electrical workman then know of what size and dimensions the conducting surface of the plates should be to charge a secondary battery when coupled up to a main so as not to damage the lamps on circuit? At that date he had never seen a secondary battery coupled up to the main for the purposes then for the first time suggested by Mr. Lane Fox: he knew nothing of what voltage would be required to charge such a battery in work, any more than Prof. Perry or Mr. Lane Fox did: he knew nothing of the nature of an incandescent lamp, and he knew nothing of what amount of voltage such a lamp would bear. In these circumstances how could he tell the size or dimension of plate area he should use in his secondary battery to do away with some unknown excess voltage? There is not a suggestion as to size given excepting that there should be "a very large conducting surface." In my judgment no electrical workman, nor do I believe any electrician of the highest eminence, could in 1878 have worked out Mr. Lane Fox's specification without both experiment and invention, and then he would have found that the system would not work automatically as described. Even in 1892 Prof. Barrett had but a hazy idea of what "the very large conducting surface" should consist. Upon this point I think the defendants are also in the right, and that there is no sufficient description of the invention in the specification. Now, as to the switches, the plaintiff is in this position. If his system of distribution can be made to work automatically without switches, no point arises upon them. If, however, as I hold, it cannot be made to work without them, then his system is not automatic, and upon this ground the switch point cannot avail him. I may, however, observe that although I have no doubt an intelligent electrical workman in the year 1878 would have known how to apply a switch to a secondary battery, that this by no means shows that he would have been able to apply the necessary number of extra cells and switches to secondary batteries in such a way as to effectively carry out Mr. Lane Fox's mode of distribution. It appears to me that the workman would, as regards these switches and extra cells, have been in a similar position of perplexity as the workman called upon to adjust cells with "a very large conducting surface." I need not recapitulate these difficulties, and the observations I have made thereon apply here. I hold also that in this respect also there is a deficient description. I have now held that this patent is bad upon the ground that the complete specification does not conform to the provisional, upon the ground that the invention as described cannot be made to work, and also upon the ground that if it could, no sufficient information is given as to how it has to be made to work, and I have stated my reasons fully (perhaps too fully) for so holding. It is not necessary to give any further judgment in this case; but had the plaintiff been able to surmount the above-mentioned difficulties, and had established that by his invention he could have brought about what the Attorney-General said he could, my judgment would have been that his invention was the subject matter of a patent, that it had not been anticipated, and that the defendants had infringed it. I give judgment for the defendants, with costs.

Savory and Moore v. London Electric Supply Corporation (Limited).

In the Court of Appeal, yesterday, the case of Savory and Moore *v.* London Electric Supply Corporation came before Lord Justice Lindley, Lord Justice Bowen, and Lord Justice Kay in the form of an appeal by the defendants from a judgment of Mr. Justice Kekewich (see *The Electrician*, December 25, 1891, p. 203). The plaintiffs are manufacturing chemists, carrying on business in New Bond-street, and they alleged that owing to the manner in which the defendants carried on their business, a fire occurred on their premises. They brought an action against the defendants, and Mr. Justice Kekewich granted an injunction restraining the defendants from so using certain portions of their buildings for converting electric currents in such a manner as to occasion a nuisance and a danger to the plaintiffs. The defendants now appealed against that judgment.

Mr. Moulton, Q.C., and Mr. Hamilton appeared for the defendants in support of the appeal; while Mr. Rigby, Q.C., and Mr. Warmington, Q.C., opposed it on behalf of the plaintiffs.

Mr. MOULTON was about to open the case for the defendants in support of the appeal when,

LORD JUSTICE LINDLEY suggested that the action should be settled. He wanted to know what Mr. Rigby required the defendants to do.

Mr. RIGBY said if the defendants would undertake to use their transformers where they said they were going to use them, the plaintiffs would be satisfied.

Mr. MOULTON said defendants would give an undertaking that no transformers should be put in the ground floor of their building until it was as fireproof as the basement was at present.

Mr. RIGBY said he should suggest precautions which ought to be taken to make the ground-floor safe.

LORD JUSTICE BOWEN asked if the plaintiffs would be satisfied if the defendants undertook to use no place but the basement of their buildings until the necessary precautions had been taken.

Mr. RIGBY replied in the affirmative. He would also like an undertaking that the defendants would not place combustibles where their transformers were.

Mr. MOULTON said the defendants would agree not to store combustibles in the room with the transformers.

It was eventually agreed that the injunction should be dissolved on the defendants paying the costs, and undertaking not to use any room of their building, except the basement, until a gentleman, appointed by the parties, was satisfied that proper precautions had been taken against fire, and not to store combustible material in a room in which there were transformers

CORRESPONDENCE.

ROTATING FIELD ELECTRICITY METERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As you have introduced my name in connection with an alternating current meter now being manufactured by the Ferranti Company, I think it right to state that the meter alluded to was invented by Messrs. Philpot and Alderton in conjunction with myself in 1888, and that a part interest in it was acquired by Mr. Ferranti in 1889. Since then it has been remodelled and clothed in Mr. Ferranti's patented double-sealed case.

As this meter formed one of the earliest examples of the rotary field motor which lately has attracted so much attention, and was certainly the first in Europe in which a rotating field was produced directly from an ordinary alternating current, I feel it is rather hard on my co-inventors to have it illustrated merely as a "Ferranti Electricity Meter."

I need hardly say that Fig. 3 on page 538 only represents in the very roughest way how the rotating field is produced, as no satisfactory motor or meter could be made with pole pieces constructed as shown in the figure, because probably the whole of the energy would be absorbed in heating the iron, instead of being gradually transmitted along the poles to the armature.

—Yours, &c., ARTHUR WRIGHT.

26, Park crescent, Brighton,
25th March, 1892.

ELECTRIC HAULAGE IN GERMAN MINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 480 of the current volume of *The Electrician* we find some particulars taken from the *Colliery Guardian* with regard to electric traction in the Neustassfurt, Zaukerode, and Hohenzollern mines. We beg to point out that all the locomotives in these three mines were supplied by this firm, and not partly, as stated by the *Allgemeine Elektricitäts Gesellschaft*. The figures given also are quite old, as they refer to about the year 1888. In the pamphlet we send herewith you will find the figures for 1891; from them you will observe the progress that electric haulage has made on these three roads.—

Yours, &c., SIEMENS AND HALSKE.

Charlottenburg, March 24, 1892.

[From the pamphlet issued by Messrs. Siemens and Halske we find that the average number of waggons hauled per day in the three mines to which we referred is at present as follows:—

Neustassfurt.	Zaukerode.	Hohenzollern.
1,200	700—800	2,000

These three lines were entirely equipped by Messrs. Siemens and Halske.—ED. *E.*]

[Owing to extreme pressure on our space, we are compelled to leave over several Letters to the Editor.]

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—The Chiswick Local Board invite tenders from electric lighting companies or other persons willing to take over the lease of the Chiswick Electric Lighting Order (1891) for the supply of electricity in the district of the Local Board, and for carrying out the duties and obligations of the Board under the Order, for a term not exceeding 21 years. Further particulars are given in our advertisement columns. Sealed tenders have to be delivered to the Chairman, at the meeting of the Board, on Wednesday, May 4th next, at 8 p.m., at the Vestry Hall. All further particulars can be obtained of Mr. Robert F. Finnis, Clerk to the Vestry, Chiswick, Middlesex.

SALE BY PRIVATE TREATY.—The machinery, plant, patterns, tools, finished and unfinished stock-in-trade, fixtures, and good-will of the National Telegraph Works Company (Limited), in liquidation, are offered for sale by private treaty, and the business is for sale as a going concern. Some further particulars are given in our advertisement columns, and full particulars can be had of Mr. James Rhodes (the receiver for the debenture holders), chartered accountant, 34, Waterloo-street; or of Messrs. Cottrell and Son, solicitors, 25, Waterloo-street, both of Birmingham.

FAILURE.—The following is the list of creditors under the failure of Mr. William D. Berry (trading as W. D. Berry and Sons), electrical engineer, Clara-street and Brook-street, Huddersfield :—

Heppenstal, G. H., Fartown	£17	0	0
Armitage, Joseph, Huddersfield	18	0	0
Liversedge, Law, Huddersfield	10	0	0
Consolidated Telephone Company, Ltd., London	39	0	0
Glover, Walter T., and Co., Salford	13	0	0
Lauder, R., and Co., West Hartlepool	62	0	0
Day, C. F., York	50	0	0
And some creditors under £10.			
Total	£342	13	9
Secured	£0	12	6
Net assets	£244	2	10

DISSOLUTION OF PARTNERSHIP.—The firm of Messrs. Dawson, Willmer, and Clift, draughtsmen and engravers, has been dissolved; and the business will in future be conducted by Mr. Leslie Everitt Clift, under the style of Leslie E. Clift and Co., at 1, Holborn-place, High Holborn, London, W.C.

BUSINESS NOTICE.—Messrs. Wynne and Barnard inform us that since the dissolution of the firm of Barnett, Wynne, and Barnard they have commenced business as electrical engineers at Grey-street, Newcastle-on-Tyne.

INCANDESCENT LAMP PATENTS.—The Edison and Swan Company issue the following caution :—"Users of the electric light are hereby specially cautioned against purchasing or using lamps now being illegally offered for sale by German makers with the assurance that they are exempt from this Company's patents. All other electric incandescent lamps than those made by the Edison and Swan Company, and marked with their name, are infringements of this Company's patents, and legal proceedings will be taken against every person found using them."

MANCHESTER ELECTRIC LIGHTING.—The Electric Lighting Committee of the Manchester Corporation have, we understand, now placed all the contracts for the work required. Messrs. Mather and Platt have received orders for two large shunt-wound-Edison Hopkinson dynamos with an output of 410 volts, 590 amperes, speed not exceeding 400 revolutions per minute, and a guaranteed efficiency of 91 per cent. These machines will be almost exactly similar to those supplied to the Central Generating Station of the City and South London Railway. The Electric Construction Corporation have also received orders for dynamos. The boilers will be supplied by Messrs. Galloway, and the machinery be driven by belts. The whole of the mains, bare copper and insulated conductors (and the laying of same), and conduits, will be supplied by the International Okonite Company. Although the system adopted by the Corporation is a low-tension one, high-class insulation has been determined upon, the specification calling for an insulation resistance of 2,000 megohms per mile. The work will be commenced directly after Easter, and the Corporation anticipate furnishing the light by about midsummer.

AN ELECTRIC SAW MILL.—An installation of wood-working machinery for Lord Rothschild has just been erected at Tring Park. The plant comprises band saw and circular saw machines, for converting logs, deals, &c., as also planing, moulding, mortising, and tenoning machines, the whole of which are driven by E.M.F. The machinery has been supplied by Messrs. A. Ransome and Co., of Chelsea, and erected under the superintendence of the resident engineer, Mr. C. Burman Callow. Although isolated machines have been driven by electricity, we believe this to be the first complete saw mill worked under these conditions.

WATER-POWER INSTALLATION.—Mr. A. A. C. Swinton has the arrangement of a water-power installation at Moy Hall, near Inverness, the residence of The Mackintosh of Mackintosh, which is being lighted with the electric light. The source of power is a water turbine, supplied by a 50ft. fall, situate at a distance of half a mile from the house. Bare copper overhead conductors, with accumulators, will be used.

THE CHICAGO WORLD'S FAIR.—We understand that the British Commissioners have decided to extend the time for receiving applications for space, and in this connection have decided to hold a meeting at Manchester. 42,000 square feet of space has up to the present been applied for, the average per exhibit being 30ft. in excess of that taken at the Paris Exhibition.—On Saturday last a credit of two million marks for Germany's participation in the World's Fair was granted by the Reichstag; and Herr von Boetticher stated that the space allotted to German exhibits at Chicago was larger than that assigned to Germany at any previous Exhibition, and that still more space would be required.

THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED.—This Company have contracted for the supply of electric light, plant and accessories for the forthcoming International Horticultural Exhibition to be held at Earl's Court. The actual lighting arrangements will be under the control of Mr. A. H. Wood, electrical engineer to the Earl's Court Exhibition Syndicate, Limited.

HYDRAULIC TOOLS AND MACHINERY.—Messrs. Woodhouse and Rawson United have sent us an illustrated catalogue of their Payne-Gallwey hydraulic machinery.

THE RATING OF MACHINERY.—The Rating of Machinery Bill is down for second reading in the House of Commons for Wednesday next, April 6th, and machinery users are earnestly requested to ask their representatives in Parliament to be in their places on that day to support the Bill. This is a subject which interests a large number of our readers, who will doubtless do all they can to assist the efforts which are being made to put the subject of the assessment of machinery on a sounder footing than at present.

THE ENGINEERING EXCHANGE.—A public meeting is to be held at the Cannon-street Hotel, on Wednesday, April 6th, at 2 p.m., to place this project in a complete and concrete form. The following outline of the features of the new Exchange will enable engineers and merchants to comprehend the manner in which it will serve their interests and convenience. The Exchange will form a central address and place of meeting for all parties interested in engineering business, and especially as a rendezvous for country members and foreigners visiting London on engineering matters. The rooms will be furnished with a view to meeting the requirements of members, who will find conveniences for correspondence, postage, periodicals, telephones for London and provinces, and boy messengers. Desks and lockers will be provided, as far as the premises will permit, for the private use of members paying a special fee in respect of same; and a patent and reference library will be established. A daily hour of meeting will be fixed by the Committee of the Exchange. The Exchange will be open between the hours of 10 a.m. and 7 p.m. daily, and later on special occasions, such as evening meetings of societies, &c. A complete set of rules and regulations, based upon those of other Exchanges, has been drafted by the hon. secretary, and will be submitted to the permanent committee, to be elected at the general meeting. The committee will be re-elected yearly, at a general meeting of members. The terms of membership will be as follows :— The first list of members, without entrance fee, £5. 5s. per annum; after the first list, £5. 5s., and an entrance fee of £5. 5s. per annum; authorised clerks of members, £3. 3s. per annum. Visitors introduced by members admitted for three weeks on payment of £1. 1s.

ELECTRO-HARMONIC SOCIETY.—A smoking concert will be held at the St. James's Hall Restaurant this (Friday) evening, at 8 o'clock.

COMPANIES' MEETINGS & REPORTS.

Notting Hill Electric Lighting Company (Limited).

The third ordinary general meeting of this Company was held yesterday at Winchester House, Old Broad-street; Prof. William Crookes, F.R.S. presiding.

The SECRETARY (Mr. W. H. Fox) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: Gentlemen, it is unnecessary for me to say much about the present position of the Company, as this is so fully gone into in the report and accounts now before you. There are one or two points, however, to which I should like to draw your attention. In 1890 you subscribed about £70,000 to be devoted to lighting our district by means of electricity. To us was entrusted the very responsible task of spending your money in the most efficient manner for the furtherance of that object. We have now spent the money in the way it was intended to

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be spent, in the purchasing of a site for the central station, in erecting on it substantial buildings and powerful machinery, in laying miles of culverts, copper mains, and cables, and in getting together a thoroughly efficient staff. We are now just beginning to reap the first-fruits of our labours. We may be compared to a farmer who, after buying a farm, and spending a large sum on agricultural machinery, seed, fertilisers, and labour, is now waiting confidently for the reward of his outlay in the shape of a heavy crop. We ourselves are in the transition state between the building up of a good business and reaping the benefit of our expenditure; and we must all exercise a little patience, for neither in agriculture nor in electric lighting will the crop follow immediately after the seed has been sown. The accounts are not quite so clear as I hope they will be in future, as they are for a broken period of seven months; and, owing to the large amount spent on capital account, many of the current expenses which under ordinary circumstances would have been charged to revenue account, are, in accordance with the Board of Trade regulations, charged to capital. Turning to Table No. III., capital account, you will see that by far the largest portion is for buildings, machinery, accumulators, and mains. Like the gas and water companies we must provide for the probable maximum demand during several years to come; for it would not be tolerated that the streets should be broken up at frequent intervals to keep pace with a rising demand. The proper apportionment of mains to streets was a subject of long and anxious deliberation on the part of your Directors and staff. It is not possible for any body of men to locate the position of greatest demand, to foresee all contingencies, and estimate the results of every move, especially when so much of the work is tentative, and there is no previous experience to serve as a guide. But our mistakes have been surprisingly few, and simply amount to this: we have put more copper strips and run more culverts in some of our streets and roads than we perhaps should have done had we been able to foresee the vagaries of the demand for current. When we first plotted out the mains and culverts, we naturally looked for most custom from the more highly-rented houses, and accordingly provided extra copper and culverts. To our surprise and disappointment, these roads have for the present brought in comparatively little, while streets in which we anticipated much less demand, have come forward in an unexpected manner, and have served to pull up the average. No particular harm is, however, done. We have only anticipated a demand which is bound to come before long. In Table No. IV., revenue, the total on each side is for seven months. Twelve sevenths of these totals come to—Expenditure, £3,733; income, £2,780; debit balance, £953. In this form the table is somewhat misleading for reasons above mentioned. I shall return further on to this subject. Table No. IX. also requires a few words of explanation. Look at the 8th column: "Quantity not accounted for, &c." This looks as if we had allowed nearly 11,000 units, worth about £340, to run to waste. I am happy to say such a reflection on our management is quite unwarranted. The "loss" of 10,996 units is accounted for as follows:—Lost in distribution: Energy expended in overcoming the resistance of the mains, being an average of 5 per cent. on the total accounts for 1,640 units; energy lost through leakage or through errors of meters, 612 units; unavoidable loss in using secondary batteries, difference between input and output, 3,958 units; used in testing meters and other apparatus, 1,025 units; energy discharged from the batteries through a water resistance during the months of May, June, July, and August, this waste was necessary in order to keep the batteries in good order. The quantity could have been sold had there been a demand, 3,731 units—Quantity not accounted for, &c., 10,966 units. This gives a total of energy lost in distribution of 18 per cent. on the total quantity accounted for, and about 11 per cent. of necessary waste. I do not think there is another company in London which can show more satisfactory figures than these. At the present time we are obliged to put up with a certain amount of loss in the use of secondary batteries; but this is far more than made up by the saving they effect. Had we no batteries, some of our most expensive machinery would have to be duplicated, and a double staff of assistants would be required, involving an expenditure of about £660 in extra wages. If we do not count the 3,731 units deliberately run to waste for the purpose of keeping the batteries in good order—a waste which can scarcely occur again—it is seen that our only real "loss" of current is a trifle of 612 units, which may be divided between errors of meters and leakage in mains. Some of the machinery would have to be duplicated, and a double staff would be required, involving an expenditure of about £660 in extra wages. Our real "loss" of current is a trifle of 612 units, which may be divided between errors of meters and leakage in mains. We opened our works at the end of May last, and with the exception of a few hours when the current was stopped owing to a burst water main flooding a culvert, the current has been on day and night without intermission. I am not aware of a single complaint as to the supply. We commenced with 22 houses and 2,411 lamps of 8 c.p., and we have at the present time 80 houses and 8,076 lamps. There are also 12 more houses, containing 976 lamps, coming on almost directly, so within about a year of our opening we shall have 92 houses and 7,052 lamps on our mains. (This does not include the houses and lamps in the proposed Phillimore district, where there are about 24 houses wired or intending to be wired.) Let me show you the significance of these figures by telling you what other companies, having, like ourselves, statutory powers in London, have done. I will first take the case of our good friends and neighbours, the Kensington and Knightsbridge Electric Lighting Company, as their system is the same as ours, their district a very similar one to our own, and their consulting engineer, Mr. Crompton, is the consulting engineer to ourselves. In 1887 they commenced with 9 houses and 360 lamps; in January, 1889, they had 61 houses and 4,425 lamps; in January, 1890, they had 141 houses and 11,359 lamps; in January, 1891, they had 291 houses and 25,355 lamps; while they commenced this year with 436 houses and 38,408 lamps. To appreciate the full significance of these figures, they must be presented in the form of a curve, such as I now put before you. The ordinates represent months and years, while the abscissæ show the number of 8-c.p. lamps on the mains at any date. The black curve gives the rate of increase of the Kensington and Knightsbridge Company from year to year. Notice how modestly they commenced with less than 500 lamps, not getting to 1,000 for more than fifteen months; and how gradual their rise was after then, until at the end of 1889 the demand increased, and the curve now looks like some high mountain peak. The red curve on the other diagram shows our own increase of lamps. Starting from the higher level of over 2,000 lamps, our curve is similar in character to the Kensington and Knightsbridge curve of 1888-89; and from all the indications I anticipate our rise will be equally marked by the time we have been in existence as long as they have. I have not been able to get quite as accurate information respecting the other companies; but I may tell you that the St. James's, the Metropolitan, the Westminster, and the House-to-House Companies also show an increase in their lamps more or less similar to the curve of the Kensington and Knightsbridge Company. On the basis of the facts before us let us see what is the present position of the Company. The accounts only give the position from May to Christmas, and they take in the summer months when we had but few customers, and some of these were away from London. In the first place, what would be our position in the impossible case of our curve of rise suddenly stopping? What if we get not a single more customer? How do we stand? Well, I think it will be satisfactory for you to know that we should be now paying our way, and even putting a few pounds to the good. From long experience the different companies have discovered that they can gauge pretty accurately the income from their lamps by multiplying the total number on their mains by a certain number of shillings, to be found out by experience. I have ascertained what this multiplier is in the case of some of the other companies, and here are the figures. The Kensington and Knightsbridge Company, in 1888, said that the revenue per lamp per annum was 13s. They now say it is a little less than 10s. The Metropolitan Company give the revenue at 12s., the Westminster consider it to be 15s., and the St. James's over 19s. The mean of all these is 13s. 10d., but; as I wish to be on the safe side, I will take 10s. per lamp per annum as our probable revenue. If, therefore, we stand still from the present time, and assume our lamps to remain at the figure above given, 7,052, our revenue should come out as follows:—7,052 lamps, at 10s. each per annum, £3,526; rent of meters and switches, £100; profit on stores, lamps, &c., £50; rents of houses, &c., £154—total £3,830. To get our expenditure I asked our engineers to give me in a tabular form the highest figures which they thought it was at all likely would be attained in any of the departments for an output based on 7,500 lamps. The table is as follows. In some cases the figures are certainly beyond the mark, but I retain them, as I wish to avoid any appearance of exaggeration:—Wages and salaries at the central station, £939; coals for 7,500 lamps, £470; petty stores (oil, waste, &c.), £75; water, £36; maintenance, £500; office expenses, Directors, secretariat, £1,400; sundries unforeseen, £100—total, £3,520. Therefore, remaining stationary at the present point, we have:—Probable income, £3,830; probable expenditure, £3,520; credit balance, £310. But it is certain that we shall not remain stationary. Even now inquiries and half promises are coming every week. The Kensington and Knightsbridge Company rose in twelve months from about 6,000 to 15,000, or two and a half times; and I see no reason why we should not rise in the same proportion. The lamp patent will expire next year, and several competing lamps will be in the market. It is expected that the price will then fall from about 4s. each to about 1s. 6d. each. This cannot fail to give a great impetus to electric lighting. Comparing the two curves before you, and interpolating our own curve in advance for twelve months, we see that the probability, almost amounting to certainty, is that by the time we have been at work for two years we shall have at all events twice the number of lamps on our mains, or say, 15,000. On the above basis of calculation our income and expenditure will then be as follows:—Income: 15,000 lamps at 10s. each per annum, £7,500; rent of meters and switches, £200; profit on stores, lamps, &c., £100; rents of houses, &c., £154; total, £7,954. Expenses: Wages and salaries at central station, £939; coals for 15,000 lamps, £938; petty stores (oil, waste, &c.), £150; water, £72; maintenance, £700; office expenses, Directors, secretariat, £1,400; interest on capital expenditure of £2,000 for crossings and extensions of mains, at six per cent., £120; sundries, unforeseen, £100; total, £4,419. Therefore, on the supposition that our lamp increase follows the normal curve, in twelve months' time we shall be working at something like the following rate: probable income, £7,954; probable expenditure, £4,419; total, £3,535. I will not dwell on the fact that to pay a 5 per cent. dividend, a sum of not more than £3,200 is required, but I cannot avoid asking you to look once more at the two curves before you, and to judge for yourselves whether it is likely we shall stop at 15,000 lamps, and a mere 5 per cent. dividend. I beg to move:—

"That the report of the Directors and the accounts to December 31st, 1891, submitted to this meeting be and the same are hereby approved and adopted."

Mr. A. E. FRANKLIN, in seconding the resolution, said that the Directors held in their own name £14,320 out of the £70,000 paid up capital, which could leave no room for doubt that they regarded their interests as identical with those of the shareholders, and was a guarantee for the good management of the business. The present quotation of the shares in the market was no criterion of the value of the Company's property.

The motion was carried *nem. con.*

The CHAIRMAN: I beg to propose—

"That Messrs. F. Radford and A. E. Franklin, the retiring Directors, be re-elected Directors of the Company."

Mr. J. T. JARVIS seconded the motion, which was carried unanimously.

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Mr. REEVES proposed—

"*That Messrs. Deloitte, Dever, Griffiths and Co., be re-elected auditors of the Company.*"

Mr. BENSON, seconded the motion, which was carried unanimously.

An extraordinary general meeting was afterwards held, at which the CHAIRMAN proposed the following resolutions:—

"*That the remaining 2,998 shares still unissued of the 10,000 shares in the Company, or such less number as the Directors may determine, be issued, and as between such shares and the other Ordinary Shares issued, or to be issued, such shares shall be Preference Shares, and issued under the title of Ordinary Preference Shares.*

"*That the Ordinary Preference Shares be entitled to receive out of the sums for the time being applicable for the payment of dividend or bonus on Ordinary Shares, a dividend at the rate of six per cent. per annum before any payment by way of dividend or bonus be made to the rest of the Ordinary Shares already issued or to be issued, and that the right of the Ordinary Preference Shares to preferential dividend as aforesaid, be cumulative, so that the deficiency (if any) of one year to pay such preferential dividend, be made up out of the sums applicable for dividend or bonus on Ordinary Shares in any succeeding year or years, before any payment, as aforesaid, be made to the rest of the Ordinary Shares.*

"*That after and in addition to the payment of such preferential dividend of six per cent. per annum, including arrears (if any) of dividend from previous years, the Ordinary Preference Shares shall also be entitled, but not until the holders of the rest of the Ordinary Shares shall have been paid a dividend for the year at the rate of six per cent. per annum, to participate with the rest of the Ordinary Shares pari passu, and without distinction in dividend or bonus available for division over and above such six per cent. per annum payable to the holders of the rest of the Ordinary Shares.*

"*That in case of any return of capital in respect of Ordinary Shares, or of winding-up, the holding of such Ordinary Preference Shares shall not entitle the holders thereof to any preference in the return of capital or in the distribution of assets, but in respect thereto the Ordinary Preference Shares shall rank as Ordinary Shares.*

"*That the time, conditions, and extent of the said issue of Ordinary Preference Shares be left to the Board, to regulate, determine and carry out.*

"*That the preferential rights in respect of the holding of the Ordinary Preference Shares are only to be as between such shares and the rest of the Ordinary Shares, and shall not under any circumstances affect, prejudice, postpone or abridge the rights under the Articles of Association of the holders of Founders' Shares.*"

Mr. S. WATERS seconded the resolutions, which were agreed to.

On the motion of a SHAREHOLDER, Seconded by Mr. REEVES, a vote of thanks was accorded to the Chairman and the other Directors.

The CHAIRMAN, in expressing his acknowledgment, assured the meeting that there was not a Company in London that had a more zealous or hard-working Board.

The proceedings then terminated.

The above resolutions will be submitted for confirmation, as Special Resolutions, to an Extraordinary General Meeting to be held shortly.

The following is an abstract of the report of the Directors of this Company to the 31st December last above referred to:—

The expenditure on capital account amounts to £67,845. 13s., in which sum are included amounts due but unpaid on December 31, 1891, for machinery, construction of works, mains, &c. The 7,002 shares subscribed have been paid up in full, and 6,318 of the ordinary shares are officially quoted on the Stock Exchange.

The Company commenced to supply current to consumers at the end of May, 1891; the revenue account, therefore, for a period of only seven months, shows a debit balance of £617. 5s. 7d. This includes a sum of £250 for Directors' fees for the quarter ending December 31, 1891, which have not been drawn, and which the Directors do not intend drawing until the Company has made further progress.

The amount of electricity sold during the quarter ending December 31st was about four times as much as that of the previous quarter. The Company has constructed and laid 5½ miles of culvert and pipes, into which has been placed 66 tons of copper strips and cable, the whole costing £26,794. 6s. 8d. These mains run past 445 houses, which can be supplied practically without further outlay, and opposite to 331 additional houses which can be supplied by simply crossing the roads.

[The district lighted by the Company's mains is shown in the map recently issued as a supplement to *The Electrician*.]

Of the houses only 77 were supplied by December 31st, the number of lights installed being equivalent to 6,056 eight-c.p. lamps. The Company has orders in hand for a further 560 eight-c.p. lamps, and is now in negotiation for many more in connection with the existing mains. It may, therefore, be fairly reckoned that the increase during the current year will be very considerable.

The Company is now in possession of a first-class central station, thoroughly well equipped, and capable of supplying current to meet largely increased requirements at a comparatively small additional outlay. It possesses freehold land in Victoria-gardens, upon a portion of which the existing works are built, the remainder being let at a remunerative rental; and seven leasehold cottages adjoining, most of which are let to the Company's workmen. The whole of this property, including expenses in connection with acquirement, has cost £7,390. The buildings which have been erected cost £10,797 0s. 10d. They are of the most solid and permanent description, and it is not expected they will require any additions or improvements for many years. Should, however, in the future, larger space be required for the works, the adjoining freehold land belonging to the Company can be utilised for extensions.

The accumulators and copper connections at the generating station have cost £4,892. 17s. 1d., and no further expenditure on this account is expected at present. The meters, switches, and cut-outs fixed on installations cost £572. 7s. 6d.; these are rented to consumers, and are a source of independent revenue. The fixed machinery has cost the Company £7,965 5s. 8d., and the works as they now stand are capable of generating sufficient electricity to supply installations aggregating 21,000 lamps; reckoning on the usual basis, proved by experience, that only one-third of these would be simultaneously used at any one time.

The Directors have contracted for an extension of the mains southward, where a considerable number of householders have promised to take current, 14 houses having been already wired in anticipation. The cost of this extension will be paid for either by the issue of preference shares at par to the contractors, or by instalments which have been arranged for on terms convenient to the Company. A site for a battery station has also been secured in the Addison-road, or S.W. district.

The Directors propose to issue the remainder of the ordinary share capital in the form of Six per Cent. Ordinary Preference shares, powers to issue which will be sought in accordance with the terms of the notice enclosed therewith. The object of this issue is to enable the Company to extend its mains to further remunerative portions of its area, and it is the intention of the Directors to give the present shareholders the first opportunity of taking their proportion of these shares.

The London Electric Supply Corporation (Limited).

The fifth ordinary general meeting of the shareholders of the London Electric Supply Corporation, Limited, was held at the Cannon-street Hotel last Friday; Mr. James Staats Forbes presided.

The MANAGER and SECRETARY (Mr. Charles B. Waller) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, I presume that as the report has been printed and circulated, you will take it as read. A good deal of my life has been passed in trying to make the best of a bad business, and it seems to me that that is what I have got to do to-day. They say you cannot inspire belief in others unless you believe in yourself; and I have been trying to find whether in these figures and this report there is really any ground for despair, or whether there is any ground for hope; and I have solved it in the figures themselves by resorting to that wonderful qualifying thing, the "if." And really I do not know that I could put it to you more graphically or more truly to represent the actual position of things than by saying this—that if something had not happened which has happened, the state of things would have been that, instead of meeting to deplore a loss, we should have met to pronounce a profit. Now, if you kindly turn to the revenue account, which is the essence of the whole business, I will present to you that proposition in the figures. It is account No. 4, page 9, and there you will see that the total outlay upon the year has been £22,517. 19s. 7d., and that the total receipts have been £15,560 17s. 11d., and that there is a loss by balance of £6,957. 1s. 8d., showing exactly the money which has been spent in excess of what has been received. And then arises my "if;" and why is this thing? Now, in 1890, the previous year, the receipts were £28,684, while in 1891, as you see, they were only £15,560; and, as I have said, if something had not happened which has happened—that is to say, that if in the interval the calamities of the Company had not led to a great number of consumers who were customers in 1890 leaving us altogether, and so reducing the year's income by £13,124—our position, of course, would have been very different. If you go to the expenses of 1890, you will find that they amounted to £28,704, while in 1891 they amounted to £22,517, and that accounts for the greater part of the adverse balance; and therefore it comes to this, that if we had remained in the position that we ended 1890 in we should have had a profit instead of a loss, and the difference would have been exactly in that shape which is so agreeable when it is in the right direction, and so disagreeable when it is in the wrong direction. The £6,100 odd of profit is turned into that amount of loss, making, of course, £12,000 to the bad. That is the long and short of our experience; and the reason we have got into this position in the current year you are already possessed of, because last March, when we met to deal with the accounts of 1890, the calamity had already occurred—the fire at the Grosvenor station—which suspended our business between November, 1890, and February, 1891; and that, of course, took away the greater part of the customers that were lighted up by us at the date of the fire. Perhaps I had better illustrate the operation of this by figures. On the 15th of November, 1890, the date of the Grosvenor fire, we had 312 customers, with 38,272 lights. Of course, when the fire came the whole thing collapsed, and for many weeks there was no supply at all. It was not until February of last year that we were able to begin to light up again, and the change of circumstances was such that, instead of having 38,272 lights, we had only 9,000, and that 9,000 has been growing from day to day almost—certainly from month to month—ever since. I will read this table, as it is rather interesting. On the 15th of Febuary we, having had that long interregnum, had devoted ourselves and the ability of all the engineers and advisers we have to starting the thing on something like a permanent basis, for you know that the Grosvenor was a mere transition machinery—a sort of pioneer machinery—and we had to remove the whole of the plant from the Grosvenor station to Deptford, so that Deptford might supersede the Grosvenor, and become the sole source of supply. A good deal of time was occupied, a great deal of money was spent, and we started in February with the belief that, at all events, we had got a machine which would run; and although we had ascertained, naturally,

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that a great many of our customers had departed, we thought we had a business which would very speedily return as a consequence of our better installation at Deptford. We had, however, to begin with 9,000 lights, and that number has gradually increased, by slow steps, until it has now reached, on the 22nd of March, 36,463; so that we have had, as it were, a whole year in order to overtake the numbers who had lights from us when that disastrous fire took place in November of the preceding year. But, unfortunately, the anticipations of the engineers, upon which we founded our expectations, were not realised to the full, because although it became an ascertained fact that current could be generated at Deptford, and could be transmitted to London, and there redistributed to the consumers, we had not attained in the first period of that experiment that perfection of the parts upon which efficiency depends, and we suffered the same kind of disaster which very often befalls experiments. The theory is right enough, but in practice it is not quite so efficient as it might be; and that is our experience. After we had started this thing, and after people began to come back to us, we had casualties—breakdowns of the mains, breakdowns of transformers, breakdowns of dynamos, interruptions of the light, and so forth; and a very serious calamity of that sort occurred in the month of November, when, from that curious coincidence of causes which it is impossible to trace—of course, there must be a cause, but it is a cause beyond the comprehension of any electrician or engineer I have been able to meet with—the whole thing came to a collapse. Dynamos, mains, and everything went wrong, and for four days or more we were without light. There was in a lesser degree what took place when the Grosvenor fire occurred. We had worked up our customers from 9,000 lights in February to 36,000 in November. Then came our disaster, and down went the numbers again, and, of course, not only did the numbers go down, but people who had not contracted to take current from this Company were alarmed. Some clubs went off, as did other people. That will all count for the state of the balance sheet at the end of the year—a disjointed year, a year which only commenced in the middle of February, and which had in itself the elements of such drawbacks arising from these accidents and break-downs as seriously to retard the progress of the business, and, in fact, to diminish the numbers of customers who from time to time had been induced to come in. That is where we are, and that is why the income, instead of being what it would have been if we had started the year with the same number of people when the Grosvenor station broke down, has shrunk by £13,000. But although the income has shrunk the expenses have remained the same, because this expensive machinery has to be carried on; and whether you light 9,000 or 36,000 lamps, the expenditure, save in the items of coal and water and some slight stores, remain the same; the fixed charges are really not in the least affected. This is what accounts for this exceedingly unpleasant result upon the year. But there is one item which one cannot carry to the profit and loss account in the balance sheet, and that is the value of the experience gained during the year. We were very anxious that the proprietors of this undertaking should know as much about it as we do ourselves, and therefore in the last two preceding reports we were very careful to have in black and white from the engineer of the Company (Mr. Ferranti) his views in unmistakable language as to the position of this experiment; and the worst that can be said about Mr. Ferranti's views is that they were somewhat too sanguine; but it looks very much like this—that the experience of these break-downs has led us to believe that they were only too sanguine, and not in principle wrong, because it may be interesting to you to know that these various accidents, interruptions to the dynamos, interruptions to the mains, interruptions to the transformers, beginning in very considerable ratio in the early months, diminished in the latter months of the year to zero. It comes to this, that the theory being right, the application or adjustment of the parts being involved, and at the same time a very delicate thing, has to be made, not in a drawing or on paper, or as an abstract proposition, but has to be felt out in practice. The result was shown the other day—I should say the other days—when London was blessed with a fog of not only great density but prolonged endurance—four or five days and nights. During that time our machinery at Deptford ran in the most perfect manner. There was no hitch or halt all these hours. It was maintained at full pressure all that time, and ran to perfection. Therefore, to sum up, we open the year with an amount of experience as to the possibility of this thing which represents, in fact, a very large value. Of course, I need hardly say that the Board room of this Company during these many months has not been altogether a bed of roses. I daresay it will be as satisfactory to you to hear as it is for me to tell you that the difficulties we have passed through and the experience we have had in these months has left our minds—I speak in the presence of most competent gentlemen—in a much happier state than at the beginning of the year and during many periods in the year. We think it is possible to develop this system of high tension to an extent and at a cost which, notwithstanding the very bad start, and notwithstanding the possible loss which will result from entering upon an experiment of this novelty, will eventually land the Company in a successful position. I do not know whether you would like me to go into much more detail. The report of the engineer is given at some length, and that is probably more worthy of your careful study than any remarks I have to make or anything in the body of the report; but for the sake of being in order I will go through the paragraphs of the report. I have told you already what the result of the year's working has been, and why it has been affected. We are now doing the whole of our work by the subterranean mains, concentric or otherwise. We lament—and I think this is the experience of some other companies—that the extension of electric lighting has not progressed with the rapidity which was anticipated. In our case I am not surprised at this, for the reason that we have had these interruptions and breakdowns. You need not be very distressed, however, if you make a loss in the first year or two. I remember a company connected with electrical supplies, with which I am also connected, which for several years showed year by year a heavy loss on the working, but the progress of that company has been such that all that loss has been wiped out with profits since, and for many years very large dividends have been paid. I do not want to be a prophet,—but it is quite on the cards that that may be the case with this Company. The expenses during this year have been reduced by £6,000, and they are susceptible of still further diminution. They have, however, as I said before, only a certain relation to the output. For instance, for the sake of the argument, suppose we doubled the output this year, the expenses would not be doubled, they would only be increased by the additional driving force—coal, water and oil. That is why the outlook is rather better than might be inferred from a superficial study of these accounts or a superficial application of knowledge. If we had had last year the same number of subscribers as we have now we should have had £6,000 to the good instead of to the bad, which is all the difference; and we must hang on to that hope. We believe it to be thoroughly well grounded. If you will refer to the capital account you will see that there are 111,000 ordinary shares of £5, issued—that is £555,000 paid up. The balance remains to be issued, making up the authorised £1,000,000 of ordinary share capital. Then the £250,000 of preference shares have been created and issued. There are some arrears of calls upon them, amounting to £6,680; but they are practically paid up. By the Articles of Association the Directors may, upon their own discretion, borrow not exceeding £250,000. If they want more than that at any time, they must come to the proprietors to ratify their deeds, but, of course, discreet Directors do not avail themselves of powers of that sort without taking their proprietors into their confidence, and having their concurrence. You see how the capital account has been made up from time to time. It is a very interesting account, inasmuch as it deals with a vast number of items, and we carry forward from year to year those items in order that some day or other, when the Local Authorities take over the electric lighting of these Companies, they may have data as to how the capital has been spent. The revenue account is also, you will see, very full. But now how do we propose to carry on? We have spent all our money, and we have only partially developed the business. Well, the present machinery, upon which we have staked our fortunes, consists of two parts—that which is now at work, and that which has been more or less constructed on the theory that it would be brought into work. We have had to stop any further expenditure that has been already incurred on the second theory, because we have come to the conviction that we had better perfect and found the business upon that part of the machinery which is in work before we proceed further. Now, that machinery existing at this moment at Deptford is capable of lighting 90,000 lamps when the drawbacks I have mentioned, arising from a little want of skill, or want of knowledge in the adjustment of the machinery, is all conquered; and it is being rapidly conquered. We have not quite enough money to carry out our programme. We are in debt, though £20,000 would cover all our indebtedness; and I am sorry to say that the bulk of that arises upon the second part of our enterprise, which is in abeyance for the present—the construction of the two 10,000 H.P. dynamos. We want a little working capital, and we also want to have enough money in hand to develop the existing machinery—to carry it to that state of efficiency which would enable us to light 80,000 or 90,000 lights. We have no money, and it is vital that we should have money, and we have been thinking how we are to get it; and, of course, with a balance-sheet like this, and a result like this of a year's work, with our shares at a heavy discount, it is not very easy to raise money. Therefore, instead of concluding to make any attempt to issue any debentures, we have arranged, subject to your concurrence, to have a loan. Now, there is one peculiarity about this Company which, I think, takes it a little out of the ordinary category. Whether the venture we are all engaged in be carried to a successful issue or not, the preponderating investment in this Company is the investment of your own Directors and their friends. They hold among them two-thirds of the entire paid-up capital. I have often heard it said that the great guarantee for the success of a joint-stock company is that the Directors themselves should hold largely in it. It is a very fortunate thing that, in the existing position of the Company, one of your own Directors should be ready to find this £50,000 that we want for a term of three years, with the option of discharging at our convenience within that time, at 5 per cent. I know of few companies who would find a Director ready to come forward and put himself in that position, and I think the service is a two-fold one. It not only relieves the Company of the possibility of a very bad financial arrangement, but it shows the confidence of that Director in his own property, for he happens also to be the largest shareholder in the Company. That Director, however, will not lend his money except on a mortgage, which will be drawn by his legal advisers and will provide remedies in the event of certain things arising; and, to be quite plain, if that loan is for three years, and at the end of three years this Company's position is such that the loan could not be met—that is to say, if things were so bad that the shareholders themselves or the public would not raise money to pay off the loan—there would be a right to foreclosure. But then, that attaches to every mortgage. It would attach, as you know, to debentures themselves, and I should not have thought it necessary to refer to this matter but for the conscientious scruples of this Director, who thought it ought to be understood that, though he comes forward now in what I may venture to say a liberal handsome manner to help the Company, he is not, because he has done so, to be precluded from the ordinary remedies of creditors at the end of the term if he cannot be paid. With the experience we have had, with most of the difficulties overcome, there seems little reason to doubt—humanly speaking, as it is said—that long before three years have expired we shall be able to issue debentures or make other financial arrangements of such a character as will enable us to discharge this loan. That is all I propose to say except in answer to questions, and I will now move the resolution:

"*That the report and accounts now submitted be approved and adopted.*"

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Lord WANTAGE seconded the motion.

Mr. PRAED said that as there was a balance of capital in hand at the close of last year of £44,000, and the Company was now in debt to the extent of £20,000, the amount expended during the present year had been £64 000. He wished to know how many lights were now being supplied.

The CHAIRMAN stated that on the 23rd of March they had 423 customers with 36,423 lights, and there were 26 customers waiting for 3,143 lamps. They were now transmitting at 10,000 volts. This gave them some trouble in the early part of the year, and was more or less the cause of the various accidents he had mentioned; but the result of this experience, and the greater development of knowledge on the part of the engineers and electricians had removed what at one time rather disturbed them - a fear whether this high voltage could be maintained. They had now come to the conclusion that it could be maintained, and if so there were great economical advantages about it. It would be a serious drawback to the Company if all the expenditure they had already incurred on the two 10,000 H.P. dynamos had been made in vain. On the other hand one could not blind oneself to the fact that the prevailing opinions of electricians was that small units were more convenient and more economical, perhaps, than large ones. They had sprung from 625 H.P. dynamos into 1,250. They had had some trouble in getting the 1,250 to go to 10,000 volts, but they thought they had overcome the difficulties; and, assuming a sufficient demand for the lighting, they were highly economical and very advantageous; they had some drawbacks, however. Assuming they were lighting 250,000 lamps, a 10,000 H.P. machine, producing enough current for the enormous number of lights, would be a very economical arrangement; but it would be a very costly one in the early hours, when pressure was not on to the full, and also in the later hours when the pressure would be diminished. What might arise was that instead of developing in the direction of these large horses they might find the multiplication of smaller horses a sounder business.

Mr. ADAMS inquired whether the loan of £50,000 was to be secured on the whole of the property, as their assets were very large.

The CHAIRMAN stated that the mortgage would naturally be on the whole of the property, but with respect to its value there were two aspects —the property as it stood in the capital account and its realizable value. Supposing the Company were to break down, for the lender only came upon the security in the event of the Company not being able to meet such a modest sum as £50,000. He did not, however, think that their undertaking was going to break down. In answer to Mr. Hill the Chairman added that they felt sure that the £50,000 would be enough to perfect the present system up to 85,000 or 90,000 lights. They did not anticipate any calamity arising to disappoint this expectation, but they would know all about it within a few months.

Mr. KISCH said that the shareholders had heard many encouraging statements at their meetings about what might be expected in the following year; but they now met with a report which he considered less hopeful than ever before. The property, though it represented considerably over £500,000, did not appear to be over-good security for a £50,000 mortgage, and they had to face the possibility that the whole of the property of the Company might be swept away to satisfy a mortgage for that comparatively small sum. The revenue account showed some startling contrasts compared with that submitted a year ago. He thought that there were no figures giving them ground for hope. Until he came to the meeting he had no idea that further capital was to be asked for. He thought that the Company was "over-officered." From his inquiries, he had gathered that a good deal of the ordering of their stores was vested in the hands of their accountant. Messrs. Savory and Moore had got an injunction against the Company carrying on business at the Grosvenor; and he desired to know how this matter stood, and how the business of the Company would be affected if the injunction should be sustained.

The CHAIRMAN, in reply, said that no stores were purchased without the matter being remitted to a special committee of the Board, and, as far as was possible, everything was got upon tender. No officer of the Company had the slightest voice in determining these matters. As to their general position, what alternative could be suggested by Mr. Kisch, who, he supposed, knew as well as he (the Chairman) did, the reason why last year had been disastrous to the Company? Misfortunes, however, were only to be redeemed by knowledge, and by courage to overcome them; and if the Directors regarded the future of the Company as so hopeless as Mr. Kisch appeared to think, they would tell the shareholders so and advise them to wind up. They were not, however, in that vein. They believed that the Company could be redeemed, but it would only be redeemed by people who had sound information and a clear conception of the remedies for patent faults, not by mere talk. They believed that the remedy was in sticking to the thing and perfecting it up to 90,000 lamps. Mr. Kisch had seemed to blame him for being sanguine, but the world was not carried on by "wet blankets." He founded his sanguineness on his knowledge of difficulties overcome in other things.

Mr. KISCH said he would propose an amendment for appointing a small committee to confer with the Board with a view to reducing the expenditure and getting the Company into a sound and paying position.

The CHAIRMAN, in replying to another shareholder, said that when Mr. Ferranti's agreement came to an end by effluxion of time they had not considered it desirable to continue that gentleman in the position of engineer, inventor and patentee, and contractor. Of course, Mr. Ferranti's agreement did not expire without the Directors taking measures for carrying on the business of the Company. As to the injunction which had been referred to, they had appealed to the Court of Appeal to dissolve it; but whether this application was successful or not, it would not be material to the interests of the Company.

Sir PHILIP MAGNUS said he would second the amendment. They had not, he said, heard who was responsible for their misfortunes, which had led to the present serious diminution in the value of the property of the Company.

Sir THOMAS BAZLEY said that for a long time he was opposed to the theory of the transmission of high voltage, but the more he thought of it the more he was gradually coming to the conclusion that it was right and that the Company's system possessed inherent qualifications which should ultimately make it successful. He visited the Company's works on the previous day, and had been very pleased with all he had seen. The machinery was working with great smoothness. He thought that the expenses required consideration.

The CHAIRMAN said he did not know who was to be the scapegoat for the present state of things; and it would be rather ungenerous, perhaps, to find one. He had been glad to hear the view expressed by Sir Thomas Bazley, who was most competent to judge of a business of this kind, that he was not in despair of the ultimate success of the system of high voltage. He (the Chairman) had had nothing to do with the policy of high tension or anything else; he had only come in as an administrator. He admitted that, in proportion to the results, the establishment charges were very large; but a vast amount of work had to be done which did not appear on the surface. The matter, however, should have full consideration.

On the amendment being submitted to the meeting, it was supported by the mover and seconder only, and the original resolution was subsequently put by the Chairman, who declared it carried unanimously.

Lord WANTAGE then proposed and Mr. Adams seconded the re-election as Directors of Mr. Forbes and the Hon. Reginald Brougham; and the motion was unanimously agreed to.

The CHAIRMAN afterwards stated that it was not necessary to submit a resolution with reference to the loan, and he gathered that the feeling of the meeting was in favour of the proposal.

Messrs. Kemp, Ford and Co. having been re-elected auditors to the Company,

A vote of thanks to the Chairman and Directors brought the meeting to a close.

Sheffield Telephone Exchange and Electric Light Company (Limited).

A special meeting of the shareholders of this Company was held on Wednesday at the Cutlers' Hall, Sheffield, Alderman George Franklin presiding.

The object of the meeting was to adopt and confirm a provisional agreement for the sale to the National Telephone Company of the telephone exchange and telephone business hitherto carried on by the Sheffield Company. The meeting, having been informed of the proposed terms of purchase, unanimously approved of the arrangement. The local Company will now be at liberty to carry on its general electrical business, together with the supply of the electric light, which it has already undertaken, and for which there is an increasing demand, and in connection with which a Provisional Order is now before Parliament, giving the Company increased powers. The terms of purchase by the National Company are such that the shareholders in the Sheffield Company will practically receive a return of the amount expended upon their telephone enterprise.

It may be mentioned that the nominal capital of the local Company is £100,000, with £43,000 paid up. The National Company take over the new telephone buildings at the bottom of Commercial-street, and a portion of the site, the Sheffield Company leasing the remainder of the land for electric light purposes. The National Company have accepted (says the Sheffield *Daily Telegraph*) a stipulation that the rates in Sheffield for telephonic communication shall not be unduly increased, in other words, that the price shall not exceed £10 for the first mile, and proportionately for greater distances.

Mr. William Johnson, secretary and engineer of the Sheffield Company has been retained by the National Company as consulting engineer. The whole of the telephone staff is taken over on the terms now in existence.

International Electric Subway Company (Limited).

The ordinary general (statutory) meeting of this Company was held on Thursday last week, at 12, King William-street, E.C.; Mr. John L. Martin presiding.

The SECRETARY (Mr. Theodore J. Ford) read the notice convening the meeting; and the CHAIRMAN, in the course of his remarks, said this was only a statutory meeting, and therefore the Directors could hardly be expected to have anything very definite to submit to the shareholders, but he would tell them what they had done and proposed doing. In the first place, under the advice of their solicitors, they had completed the purchase of all the patents for the United Kingdom and Europe of the Johnstone system of underground electrical conduits. This system is extensively used in the United States, several hundred miles of the conduits being laid in New York, Chicago, and Philadelphia, and large contracts are now being carried out in other of the principal cities of America. The system has been so extensively adopted in America, because of its economy and permanency, that he did not think it an exaggeration to say that it is the standard system of electrical conduits in use in America to-day. Their system was one by which wires are laid in rectangular iron boxes with interior subdivisions. The upper part of the conduit, as also the lower part, is made in sections of 5ft., so arranged as to break joints at any point where it may be necessary. The wires in the conduits can be made easily accessible without disturbing them or pulling them through long lengths of pipe, and this can be done by simply lifting off the top piece at any point desired. In addition, the man-holes and connections could be put in at any point

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desired at small cost. The whole of the conduit is made of cast iron, and they were prepared to take contracts and lay our system for the same money as any other system now in use; and the Company claim that they will give for the money very much better results in the way of permanency, safety, and facility of handling and operation. Their energetic managing Director had secured the attendance at their offices of many engineers interested in electrical subway conduits from various parts of England, and had explained their system to them, with the result that the Directors believe they are on the eve of obtaining large and substantial orders in various of the principal towns in England, and even within the precincts of London itself, and also in Paris. A full-sized model of the Johnstone system was on view in the Crystal Palace. It should be remembered that this Company was really a pioneer syndicate, with a capital of only £25,000, and, as their system became more widely known, the Directors believe that they will be able to dispose of their rights on very favourable terms to the various European countries.

A vote of thanks to the Chairman terminated the proceedings; and at an extraordinary meeting subsequently held, the Directors' remuneration was fixed at £250 per annum.

Telephone Company of Egypt (Limited).

The following report has been issued by the Directors of this Company for the year ended December 31 last, and is to be presented at the ninth ordinary general meeting of the Company, to be held at the offices of the Company, 14, Austin-friars, London, E.C., on Tuesday next, the 5th inst., at 12:30 o'clock:—

The revenue account shows a balance to credit of £4,053. 16s. 1d., after payment of debenture interest; adding to this the sum of £1,508. 5s. 5d., brought forward from December 31, 1890, there remains a balance for disposal of £5,562. 1s. 6d., which the Directors propose to deal with as follows:—To pay a dividend of 6 per cent. on the preferred shares, free of income tax; to transfer £525. 18s. 6d. in reduction of capital expenditure; and to carry forward £1,414. 17s.

A small exchange was opened at Suez on July 14th, communicating with Port Thewfick, and although the demand for telephonic service must at these places necessarily be restricted, the Directors are desirous of meeting the public wants in the matter of telephonic communication so far as lies in their power. The support that has been given is sufficient to pay expenses in the meantime, but an extension of the system is hoped for.

At Mansourah, although the terms of subscription were fixed as low as possible, many of the original subscribers had from time to time withdrawn, the demand for telephone inter-communication having been found very limited. Under advice of the Company's manager, the "exchange" service has now been discontinued, but arrangements are in progress with several firms for the rental of some of the existing lines for private use.

On the whole, considering the wave of commercial depression that has passed over the country, the result of the year's business is not unsatisfactory. The profits realised from sales of material, &c., have more than made up for the falling off of revenue at one or two of the smaller branches, and from the accounts now published some doubtful subscriptions have also been excluded.

The gross revenue of the Company at December 31st was £11,263, and the total number of lines, exchange and private, 1,041.

The retiring Director at the present meeting is the Chairman, General Alexander Fraser, C.B., R.E., who, being eligible, offers himself for re-election. Messrs. Price, Waterhouse, and Co., the auditors of the Company, also retire, and offer themselves for re-election.

The House to House Electric Light Supply Company (Limited).

The following report is issued by the Directors of this Company to December 31st last. The meeting takes place at Richmond-road, Kensington, on Tuesday next, at 3 p.m.:—

The revenue account shows a credit balance of £2,250 9s. 1d.; which, with the balance of £385 15s. 8d., brought forward from the previous year, making a total of £2,636. 4s. 9d., is sufficient to cover—

Interest on £30,000 debentures	£1,706	0	0
Ten per cent. to be written off preliminary expenses	542	9	9
Proposed dividend of seven per cent. on £1,710 preference shares	113	9	7
Leaving a balance to be carried forward of..... ..	274	5	5
	£2,636	4	9

During the past year the business of the Company has steadily increased, the number of 35 watt lamps attached to the Company's circuits on the 1st January being 13,665, and on the 31st December, 19,388. At the beginning of the year there were 248 houses connected, and at the end of the year, 373. A special unit of plant has been laid down, by means of which it is not only possible to supply a greater number of lamps, but the lighter load during the period of minimum consumption is more economically dealt with. Important extensions of the Company's mains have also been carried out.

Since the end of the year, the Directors have allotted £12,290 of Seven per Cent. Preference Shares, bringing the total preference capital issued up to £14,000, out of the proceeds of which it is proposed to lay down further plant to enable the Company to cope with its increasing business; and, as the new business will probably entail but little addition to the standing charges, it may be confidently anticipated that the profits for the current year will show a substantial improvement on those of 1891.

An agreement, which, it is hoped, will in future provide a satisfactory addition to the profits earned at the West Brompton Station, has been entered into with the Leeds and London Electrical Engineering Company (Limited), by which agreement that Company will carry on the business built up by the Company for the construction of central stations.

The following is a comparative statement for the past two years:—

Working Expenses.		——	Revenue.	
1890.	1891.		1890.	1891.
£1,921 0 7	£3,118 2 9	Jan. 1 to June 30	£1,373 6 7	£3,838 0 6
£2,703 5 10	£2,889 12 5	July 1 to Dec. 31	*£3,637 2 7	£4,490 3 5
£4,624 6 5	£6,007 15 2		£5,010 9 2	£8,328 3 11

* Very foggy December.

The Directors have drawn no fees during the past year, but £200 has been paid to Mr. William Page, for special services. They congratulate the shareholders upon the promising position of the Company's business. Thanks are due to the manager and staff, who have so materially aided in placing the working of the enterprise on a satisfactory basis.

During the past year Mr. W. F. Leese and Mr. Joaquin de Galindez have been elected Directors, and their election is now brought forward for confirmation by the shareholders. Mr. H. R. Beeton and Mr. Robert Hammond retire by rotation, and offer themselves for re-election. Messrs. Theobald Bros. and Miall, the auditors, retire, but, being eligible, offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "The Electrician" Electrical Trades Directory and Handbook, 1892, pages 308-322, *&c., &c.*]

ASSOCIATION FOR THE PROTECTION OF TELEPHONE SUBSCRIBERS (LIMITED).—At last telephone subscribers are to be "protected," and our readers will enjoy the humour of the following registration. It will be noticed that among the subscribers are a wine and spirit merchant, a wholesale druggist, a chartered accountant, an electrical engineer, a colonial broker, a Mincing-lane merchant, and, to savour the whole, a solicitor. If telephone subscribers are not sufficiently "protected" with such a representative body as this, what hope can there possibly be? The Association was registered on the 25th March as a company limited by guarantee by, we understand, Messrs. Hasties. For the purposes of registration, the number of members is declared to be 20, and each of these undertakes to contribute to the assets of the Association, in the event of winding-up while he is a member or within a year afterwards, a sum not exceeding £1. Amongst the objects are: To "assist and protect" telephone subscribers in the United Kingdom, and particularly those of London and its neighbourhood. The subscribers are:—

C. R. Haig, 12, Mark-lane, E.C., *wine and spirit merchant.*
Charles G. Clarke, 5, 6, and 7, Raven-row, E., *wholesale druggist.*
William C. Jackson, 58, Coleman-street, E.C., *chartered accountant.*
Frederick Lawrence Rawson, 88, Queen Victoria-street, E.C., *electrical engineer.*
H. R. Oscar Thompson, 38, Mincing-lane, *colonial broker.*
C. Hubert Hersey, Dunster House, Mincing-lane, *merchant.*
A. H. Hastie, 65, Lincoln's Inn Fields, *solicitor.*

Until Directors are appointed, the subscribers shall, for all purposes, be deemed to be Directors.

BLACK, HAWTHORN, AND CO. (LIMITED).—This Company was registered on March 23, 1892, with a capital of £110,000, in £10 shares, by Jordan and Sons, 120, Chancery-lane, London, W.C. The objects are to acquire and carry on the business of builders of locomotive, marine, and stationary engines, and of general engineers, and manufacturers of, and dealers in, iron work, carried on by William Black and others at Gateshead-on-Tyne, under the style of Black, Hawthorn, and Co.; to carry on the business of engineers and makers of, and dealers in, iron, steel, brass, copper, &c., general merchants, and mechanical, electrical, and chemical engineers, and "to carry on any business or businesses directly or indirectly connected with the generation, accumulation, distribution, supply, or application of electricity."

PONTYPOOL ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—This Company was registered on March 28, 1892, with a capital of £10,000, in £5 shares, by Waterlow Brothers and Layton (Limited), 24 and 25, Birchin-lane, E.C. The objects are to generate, produce, store, accumulate, distribute, and supply electrical energy, or other similar energy, whether in the form of light or motive power, in and to streets, public places, public and private buildings, manufactories, mines, railways, tramcars, or other places, or to generate, supply, and sell such electrical energy for the purpose of plating, combining, separating, or otherwise working in metals, or for carrying out or facilitating any mechanical operation; and to erect, construct, lay down, manufacture, and maintain all such generating stations, works, mains, electric lines, and other appliances as may be considered necessary; to acquire the right to use or manufacture and put up telephones, telegraphs, electric bells, phonographs, and all electrical apparatus. Amongst the subscribers are:—

	Shares.
Mr. William Pegler, Jun., George-street, Pontypool, merchant	100
Jno. C. Howell, 24, Queen Victoria-street, London, E.C., electrical engineer	100

The first Directors are W. Pegler, Jun., E. B. Ford, W. Sandbrook, J. Herbert, and J. C. Howell.

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BERNSTEIN ELECTRIC LAMP COMPANY (LIMITED).—The annual return of the above-named Company, made up to December 31, 1891, was filed on March 15, 1892. There has been no annual meeting held for the year 1891. The Company was registered on July 29, 1885, with a capital of £100,000, in £10 shares, to purchase the British Letters Patent, No. 2,604 of 1882, No. 6,075 of 1882, and No. 3,915 of 1883, and the patents for the inventions, or some of the inventions, protected by such British letters patent, obtained or applied for by Alexander Bernstein in and for Belgium, Denmark, Sweden and Norway, and Russia respectively, and to carry on the business of manufacturers of and dealers in apparatus for producing and supplying electricity, whether for the purpose of lighting or otherwise. An agreement dated August 1, 1885, with J. T. Brunner, Julius Maier, A. Bernstein, and Ludwig Mond determined that in consideration of the above-mentioned patents, all of which were for "Improvements in Incandescent Electric Lamps," £11,000 in fully paid-up shares be allotted as follows:—J. T. Brunner, 150 shares, numbered 10 to 159 inclusive; Ludwig Mond, 150 shares, numbered 160 to 309 inclusive; Alexander Bernstein, 600 shares, numbered 310 to 909 inclusive; and Julius Maier, 200 shares, numbered 910 to 1,109 inclusive. A royalty of 2½d. for every lamp constructed by the Company or any licence of the Company was to be paid half-yearly to the said A. Bernstein. At the time of making up 2,814 shares had been taken, and, according to the return, the full amount called and all calls (£28,140) paid. This, however, does not give any account of the shares issued as fully paid in accordance with the above agreement. The principal shareholders are Alexander Bernstein, electrician, of Mühlenkamp, Hamburg (1581); J. T. Brunner, alkali maker, of Winnington Hall, Northwich (400); and Ludwig Mond, chemist, of 20, Avenue-road, London, N.W. (801). Registered office: 40, Chancery-lane, London, W.C.

BISHOP'S STORTFORD ELECTRIC LIGHT AND STEAM LAUNDRY COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 26, 1891, was filed on March 11, 1892. The annual return was also filed on March 11, 1892. No change has been made. Registered office: North-street, Bishop's Stortford.

CITY OF BATH ELECTRIC LIGHTING AND ENGINEERING COMPANY (LIMITED).—The first annual return of the above-named Company, made up to March 12, 1892, was filed on March 19th. At the time of making up, 3,246 ordinary and 50 founders' shares had been taken up, of which 2,250 ordinary and 50 founders' shares had been issued as fully paid. (It will be noticed that only 2,250 ordinary shares are here said to be issued as fully paid, and no notice of the change has been given to the authorities.) Upon the remaining 996 ordinary shares the full amounts have been called, resulting in the payment of £9,835, and leaving £125 in arrears. The principal shareholders are the Brush Electrical Engineering Company (Limited), 49, Queen Victoria-street, E.C. (600 ordinary and seven founders' shares), Emile Garcke (50 ordinary), Laing, Wharton and Down Construction Syndicate (Limited), 82A, New Bond-street (216 ordinary and four founders' shares); Alfred Pitman (100), Ernest Pitman (100), and Isaac Pitman and Sons (160), all of 12, Royal-crescent, Bath; Henry G. Massingham, of Bath (504 ordinary and 33 founders' shares); Colonel A. S. Haghan, of Norwood (50 ordinary); E. B. Titley, of Bath (250 ordinary); Lieutenant-Colonel T. Vaughton, of Bath (60 ordinary); Callender's Bitumen Telegraph and Waterproof Company (Limited), of 101, Leadenhall-street (550 ordinary and six founders' shares); and E. Garcke and T. O. Callender jointly (100 ordinary).

CITY OF WESTMINSTER ELECTRICAL SYNDICATE (LIMITED).—The annual return of the above-named Company, made up to December 31, 1891, was filed on March 16, 1892. The Company was registered on July 11, 1888, with a capital of £10,000, in £1 shares. At the time of making up (31st December, 1891), the 10,000 £1 shares had been taken up, the full amount called and all calls paid. A note on the return states "That no meeting was held during 1891, the syndicate having been acquired by the Westminster Electrical Supply Corporation (Limited), and it is now in the process of voluntary liquidation."

ELECTRICAL ACCESSORIES COMPANY (LIMITED).—The annual return of this Company, made up to January 14, 1892, was filed on March 15th. The Company was registered on September 28, 1889, with a capital of £5,000, in £1 shares. At the time of making-up, 1,957 shares had been taken up, of which 1,500 had been issued as fully paid in accordance with the above-mentioned agreement. Upon the remaining 457 shares, the full amount has been called, and all calls have been paid. Another return, made up to February 15, 1892, was also filed on March 15th, 2,257 shares had been taken up, of which 1,500 had been issued as fully paid. Upon the remaining 757 shares the full amounts had been called and all calls paid. In the former return B. M. Drake, of 66, Victoria-street, S.W., electrical engineer, held 1,503 of the 1,957 shares taken up, but these have been transferred. Mr. C. L. Schwind is now Managing Director.

KESWICK ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 12, 1892, was filed on March 21st. The Company was registered on May 1, 1889, with a capital of £5,000, in £1 shares. At the time of making up, 3,420 shares had been taken up, and upon 2,355 of these the full amount had been called, while upon the remaining 1,065 shares, 10s. per share had been called, resulting in the payment of £2,887. 10s. The majority of the shares are taken up by the residents of Keswick and district.

NONPAREIL ELECTRIC SYNDICATE (LIMITED).—The annual return of the above-named Company, made up to December 31, 1891, was filed on March 23, 1892. The Company was registered on August 13, 1890, with a capital of £6,000, in £10 shares. At the time of making up 400 shares had been taken up, of which 200 had been issued as fully paid; upon the remaining 200 shares the full amount had been called, and all calls (2,000) had been paid. Registered office: 2, Victoria-mansions, Victoria-street, Westminster, S.W.

NORTHAMPTON ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of this Company, made up to March 10, 1892, and filed on March 21, 1892, shows that out of a capital of £50,000, divided into 10 "A" and 49,990 "B" shares of £1 each, 10 "A" and 10,000 "B" shares have been taken up. The full amount had been called and paid on the "B" shares, while upon the "A" shares no calls have been made.

RAILWAY AUTOMATIC ELECTRIC LIGHT SYNDICATE (LIMITED).—The annual return of the above-named Company, made up to February 15, 1891, was filed on March 11, 1892. The Company was registered on February 26, 1889, with a capital of £10,000 in £25 shares. At the time of making up all the shares had been taken up, of which 200 had been issued as fully paid. Upon the remaining 200 shares £15 per share had been called resulting in the payment of £2,886, and leaving £114 in arrears.

SHIPPEY BROTHERS (LIMITED).—We have received the following from this firm:—Summary of capital and shares made up to December 31, 1891. Nominal capital, £30,000, divided into 6,000 shares of £5 each; number of shares taken up to December 31, 1891, 2,412; called up on 612 shares, £3,060; total amount of calls received, including payment on application and allotment, £3,060; total amount agreed to be considered as paid on 1,800 shares, £9,000; total amount of calls unpaid, nil.

SUNBEAM LAMP COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 12, 1892, was filed on February 22nd following. The Company was registered on December 13, 1887, with a capital of £25,000, in £10 shares, to manufacture, sell, and deal in incandescent electric lamps. At the time of making up, 2,213 shares had been taken up, of which 2,000 had been issued as fully paid. Upon the remainder the full amount has been called, resulting in the payment of £2,100, and leaving £30 in arrears.

TAUNTON ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 14, 1892, and filed on March 18th, shows that out of a capital of £20,000 in £5 shares, 2,569 have been taken up and 787 have been issued as fully paid. Upon the remaining 1,782 shares the full amount has been called, and all calls (£8,910) have been paid.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LTD).—The annual return of the above-named Company, made up to March 15, 1892, was filed on March 24, 1892. The nominal capital is £448,200, divided into 37,350 shares of £12 each. All the shares have been taken up, the full amount called, and all calls (£448,200) paid.

WINDSOR AND ETON ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 11, 1892, was filed on the same day. The Company was registered on November 24, 1888, with a capital of £20,000, divided into 5,950 ordinary shares of £5 each, and 250 founders' shares of £1 each. At the time of making up, 250 ordinary shares had been taken up and the full amount called, resulting in the payment of £1,192, and leaving £58 in arrears.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—An interim dividend has been declared by the Directors of this Company for the quarter ending 31st March, 1892, of 12s. 6d. per cent. on the ordinary stock, and 25s. per cent. on the preferred stock, less income tax, payable on the 30th April to the stockholders registered on the books of the Company on 31st March, 1892.

CALLS DUE.—15s. (final) on ELMORE'S AMERICAN AND CANADIAN PATENT COPPER DEPOSITING COMPANY'S £2 Priority shares (*April 1*).

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended March 27th were £618, as against £702 in the corresponding period of last year, showing an increase of £116. The total receipts to date, from January 1, 1892, are £10,545, against £9,183 for the corresponding period of 1891, an increase of £1,362.

DIVIDENDS DUE.—*April 1*, COMMERCIAL CABLE COMPANY, quarterly div. at the rate of 7 per cent. per ann. (less income tax); DIRECT SPANISH TELEGRAPH COMPANY, 4 per cent. for half-year (eq. 4½ per cent. for year to Dec. 31, 1891); *April 14*, EASTERN TELEGRAPH COMPANY, interim of 2s. 6d. per share (eq. 10 per cent. per annum) for quarter ended Dec. 31, 1891. *No date fixed*, KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY, 2 per cent. for year ending Dec. 31, 1891 (less income tax); ORIENTAL TELEPHONE COMPANY, 2¼ per cent. for year to Dec. 31, 1891 (eq. to £3. 12s. 2d. per cent. for year on ordinary shares, 11s. paid).

EVERED AND CO.—The Directors of this Company recommend that, after providing for debenture interest amounting to £2,437, a dividend at the rate of 7½ per cent. per annum be paid for the six months ended 31st December, 1891, making 7½ per cent. for the year; and also that a bonus be paid for the year of 2½ per cent., that £1,000 be written off plant, &c., and £3,000 placed to the reserve fund (making it £23,000), and that £3,325 be carried forward to the next account.

FAREHAM ELECTRIC LIGHT COMPANY (LIMITED).—The annual general meeting of the shareholders of this Company was held recently at the Red Lion Hotel, Fareham. The Directors' report showed that the past year's working, after providing for interest on the debenture bonds, precluded the paying of any dividend on the ordinary shares of the Company. The report states that the public lighting of the principal streets met with the general approval of the inhabitants, and had been most favourably

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reported on by deputations from Blackpool and elsewhere. The report also stated that the duplicate plant would be in running order within a few days, and then any little irregularity in lighting that occurred in the past would be avoided. The balance-sheet to December 31st last showed capital and liabilities: 4,158 shares (£1 called), £4,154; arrears of calls, £4; debentures, £2,295; debts due to tradesmen for supplies of plant, stock-in-trade, and other articles, £455. 13s. 7d.; interest on debentures, £20. 5s. 10d.; total, £6,928. 19s. 5d. Property and assets: Electric light station, £350; stock-in-trade, £123. 0s. 2d.; plant, £5,363. 14s. 7d.; debts considered good, for which the Company hold no security, £273. 18s. 11d.; cash at National Provincial Bank, £234. 16s. 1d.; cash in hand, £39. 16s. 11d.; balance forward December 31, 1890, £149. 1s. 6d.; loss, £394. 11s. 3d.; total, £6,928. 19s. 5d.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—The thirteenth general meeting of this Company was held on Thursday, March 24, and we have received a notification from the Company that the report and accounts for the year ended December 31st last were adopted unanimously. After writing off £6,757 from ship gear and patents, and providing £10,000 in reduction of "B" debentures, dividends at the rate of 7 per cent. per annum on the preference shares, and 5 per cent., free of income-tax, on the ordinary shares, were declared, and a balance of £11,731 carried forward to current year's account.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ending March 25, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,106.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, March 23.		Price Wednesday, March 30.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending March 30.	
										Highest.	Lowest.
			TELEGRAPHS.					£ s. d.			
£1,300,980	Stock	16/0	Anglo-American	49⅞	50⅛	49½	50½	4 19 0	Jan., Apr., July, Oct.	49½	..
£2,849,510	Stock	32/0	Do. Preferred	88½	89½	88½	89½	5 17 4	" "	89⅜	89⅜
£2,849,510	Stock	5/0	Do. Deferred	11⅜	12⅛	11½	12	..	" "	11⅝	11½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	..	..
130,000	£10	3/0	Brazilian Submarine xd	10⅜	11½	10⅜	11½	7 2 3	Mar., June, Oct., Dec.	11⅜	1⅜
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	151	156	155	160	4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	10	11	10½	11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	..	..
12 931	5	2/0	Direct Spanish (£4 paid) xd	3¼	3⅜	3¼	3⅜	6 18 8	April and October	..	..
6,000	5	10%	Do. Preference 10% xd	8½	9½	8½	9½	5 5 3	" "	9	..
60,710	20	3/6	Direct United States	11½	11⅝	11½	11⅝	6 3 4	Jan., Apr., July, Oct	11⅝	..
400,000	10	2/6	Eastern	14⅜	15	14⅜	15	4 3 4	" "	15⅛	14⅝
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15⅜	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108	111	108	111	3 12 1	May and November	111	110
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅜	15⅛	14⅜	15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	14⅜
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	106	109	106	109	3 13 5	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	102	105	102	105	4 15 3	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	101	104	101	104	4 16 2	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	100	103	99	102	3 18 5	February & August	..	..
180,227	10	1/6	Globe Telegraph and Trust	9⅞	10⅛	9⅞	10⅛	5 6 2	Jan., Apr., July, Oct.	10⅛	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15⅛	14⅜	15⅛	3 19 10	" "	15⅛	14⅜
180,000	10	5/0	Great Northern	18⅜	19⅛	18⅜	19⅛	4 8 4	Jan., April, and July	18⅛	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	7⅛	8	7⅛	8	5 3 2	April and October	..	..
3,881	£100 Cert.	6%	Submarine Cables Trust 6%	115	120	115	120	5 0 0	" "	..	..
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	3½	4½	3½	4½	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	..	..
88,321	10	1/0	West India and Panama	1⅛	1⅞	1⅛	1⅞	..	" "	1⅛	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10⅞	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8½	9½	8½	9½	6 6 4	" "	..	..
67,007	15	6/0	Western and Brazilian	10	10½	10	10½	7 2 10	" "	10½	10
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6½	6⅝	6	6½	5 15 3	" "	6⅝	6½
30,364	7½	7/6	Do. 5 per Cent. Deferred	4	4½	4	4½	..	" "	4½	4⅜
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	97	100	97	100	6 0 0	March & September	..	..
			TELEPHONES.								
£34,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜	½	⅜	½	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	⅛	⅜	⅛	⅜	6 3 11	Yearly	..	..
438,984	5	2/6	National	4⅛	4⅜	4⅛	4⅜	6 9 9	June and December	4⅛	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13½	12½	13½	4 8 11	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	11½	12½	11½	12½	4 16 0	" "	12	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	105	107	105	107	4 4 1	January and July	106⅜	106
58,000	5	1/0	United River Plate	2	3	2	3	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£8 paid)	7½	8	7½	8	..	—	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	..	..
8,332	£5	..	House to House Electric	4½	5	2⅞	3½	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5⅝	6	5⅝	6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5⅝	6	5⅝	6	..	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 paid)	2⅝	2⅞	2⅝	3	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	4⅝	5	5	5⅛	..	March	..	..
111,000	5	..	London Electric Supply	⅝	1⅛	⅝	1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8½	9	8½	9	..	..	8⅞	8⅝
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4½	5⅛	3⅞	4⅛	..	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8	8½	8	8⅝	—	..	8⅝	8⅜
7,900	£5	7%	Do. 7% Preference	7½	7⅝	7½	7⅝	..	..	7⅝	7½
42,853	5	..	Westminster Electric Supply (fully paid)	6¼	6½	6¼	6¼	..	..	6⅞	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1/9	Brush Electrical Engineering	3½	3⅝	3½	3⅝	..	..	3½	3½
69,996	2	6%	Do. 6 per Cent. Preference	2⅝	2⅝	2⅝	2⅝	5 1 1	..	2½	2⅞
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼	6	5¼	6	5 16 8	January and July	5½	..
17,139	5	17½	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	6	6½	5⅜	6½	..	—	6⅛	6⅛
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜	3⅛	2⅜	2⅝	..	—	2⅛	2⅛
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	19½	20½	19½	20½	4 17 7	February & August	20½	19⅜
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104	107	102	105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	4	5	4	5	..	..	..	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅜	½	⅜	½	..	..	..	..
78,249	5	5/7½	Swan United (£3. 10s. paid)	4	4½	4	4½	8 11 10	May and November	4⅝	4⅜
36,250	12	36/0	Telegraph Construction and Maintenance	43	45	42	44	5 9 1	March and July	43½	42½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½	1	½	¾	4 10 0	..	..	..
—	£5	8%	Do. Preference (fully paid)	2½	2⅝	2½	2⅝	11 0 0	—	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
60,000	£10	—	City and South London Railway	2⅛	3⅛	2⅛	3⅛	..	—	..	..

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NOTES.

The case of King, Brown and Co. *v.* The Anglo-American Brush Electric Light Corporation came before the Court of Session in Edinburgh on Tuesday, November 27th, 1888 (*The Electrician*, Vol. XXII., p. 111). Judgment was delivered by Lord Trayner for the plaintiff with costs on Wednesday, June 26th, 1889 (*The Electrician*, Vol. XXIII., p. 200). Against this judgment the Brush Corporation reclaimed to the First Division, that is, appealed. The Lord President and Lords Adam and McLaren on Wednesday, July 16th, 1890, upheld the judgment of Lord Trayner with costs (*The Electrician*, Vol. XXV., p. 291). On Tuesday last, April 5th, 1892, the Lord Chancellor, Lord Watson, and Lord Herschell delivered judgment in the House of Lords, Lords Macnaghten and Field concurring, affirming the judgment in appeal. Their Lordships' judgments will be found in full elsewhere in the present issue.

The truly gigantic contract for the arc lighting of the Chicago Exhibition has given rise to a squabble of appropriate dimensions. Tenders were asked by the Bureau of Construction for the supply of dynamos and auxiliary apparatus sufficient to run 6,000 2,000 c.p. arcs. On March 15th a committee assembled to find that only one tender—that of the Thomson-Houston Company—was really before them. This Company offered to furnish the lights for $38\frac{1}{2}$ per lamp, which would mean $231,000 or £46,200 for the arc lighting of the entire Exhibition. The Western Electric Company had indeed offered to be responsible for 500 lights at $31\frac{1}{4}$ each, but did its best to withdraw this offer before the tender was opened. As the Exhibition authorities had been led by a representative of the Edison Company to anticipate a charge of only $15 per lamp, and by a representative of the Thomson-Houston Company itself a charge of not more than $20, the demand for nearly double the latter sum was "peremptorily rejected."

There are two sides to every question. The Exhibition authorities consider the price demanded an exorbitant one, and declare that the Electrical Companies have wickedly combined to "sandbag" the Fair, whatever that may mean. One eminent gentleman has indeed unbosomed himself to a reporter thuswise: "The idea of the Edison Company refraining to come in on a contract as big as this is enough to make us all sick. It indicates, too, we think, that the big companies have struck hands and divided up the work to be done on some basis satisfactory to themselves."

The Thomson-Houston Company, on the other hand, denies all idea of extortion, and marshals a formidable array of facts and figures to show that its charge is astonishingly moderate, considering the conditions imposed. The task of lighting the Chicago Exhibition by arcs is, in its opinion, "something beyond the capacity of any other firm on the face of the earth, and the nerve in submitting an estimate for the entire installation is something that should receive due credit."

This way of looking at the matter has, however, failed to commend itself to the Bureau of Construction, whose representative is now on his way to Europe, "to confer with the manufacturers of electrical machinery in reference to lighting the World's Fair." It is to be hoped that the net result of all this pother will be the installation of some fine samples of English central-station practice on the shores of Lake Michigan.

In a report to the Electric Lighting Committee at Bath, Mr. Gatehouse states that the public arc lamps were properly described as 1,200 c.p., though they did not give an effective candle-power of 1,200 candles as used in the streets, surrounded with ground glass or opal globes. The inhabitants of Bath are to be congratulated on having lamps which actually emit their nominal candle-power; these are almost as rare as reputed pints which will hold 20 fluid ounces. Mr. Gatehouse found that ground-glass globes, when clean, absorb 42 to 46 per cent. of the light, and opal globes from 54 to 70 per cent., and absorbed a larger percentage than that when not properly cleaned. These figures are rather high. A 70 per cent. globe is not rare; but, as a rule, no one but a gasfitter would think of supplying them. Ground glass may absorb less than 20 per cent., and generally ranges between 25 and 30 per cent. Prof. Forbes has stated that "little if any light was necessarily lost by the use of frosted bulbs, and what was absorbed was due to the dirt which the frosting collects." This statement caused some surprise at the time; but we have since heard from the same authority, under oath, that a difference of 15 volts on an 85-volt lamp would make no difference in the light perceptible to any one but an expert, and that most people not electricians would not notice it.

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How far these statements agree with general experience it is not necessary to discuss, but they are fairly in accord with each other. One of the most agreeable kinds of globe has a thin layer of opal glass "flashed" on a clear body, and then frosted or etched. Nothing is more difficult to clean than the old-fashioned ground glass. A maximum of 30 per cent. should never be exceeded for arc lights.

Nearly six months ago we commented on the regulator socket for glow lamps, and pointed out that there could be no perceptible saving in its use, and what saving was effected at the lamp would fail to be recorded on most meters. Further particulars of this socket have recently been published, and the results of some tests of it will be found in another column. By the so-called efficiency of the arrangements is meant the ratio of the total watts used in the filament to the total watts given to the lamp. But this efficiency has little to do with the use of the socket for electric lighting, and can only be applied to its use in connection with heating or warming.

We have calculated the cost of the lighting with a regulator socket, assuming that a 16 c.p. lamp costs 8d. for 15·6 hours, giving, say, 2,500 c.p. hours. When the switch is turned to contact No. 1 the light of an ordinary Edison Swan lamp would drop to 9·7, or 60·5 per cent. If the reduction in light were made by a thick shade, the current remaining the same, the cost per candle hour would be nearly double, *i.e.*, 1s. 1½d. There is, however, with the Ries regulator, a saving of 8·2 watts, or 14 per cent. of the energy, which brings the cost to 11·4d. The cost per lamp, reckoned by time only, neglecting the light, would be about 6·9d., as against 8d. Say half the light turned off and only one penny saved. The switch being turned to No. 2, the light of a 16 c.p. lamp would be about 5·6. About two-thirds of the light would be shut off, and the saving per lamp would be 2d. with a meter reading true watts, or 1·4d. if apparent watts were recorded. The cost of 2,500 candle hours with the switch at No. 2 would, with a true meter, be 1s. 5¼d. while if the light were merely cut off by a shade, the current remaining the same, the cost would be nearly 1s. 11d. The efficiency of a choking coil if used for electric lighting should take into account the efficiency of the lamp. Choking coils may no doubt be useful for many purposes, and their design and efficiencies have at present received very little attention.

We publish this week a valuable investigation by Prof. J. J. Thomson on the effect of eddy currents in modifying the distribution of the lines of force in the iron cores of transformers; and in our next issue we shall be able to place before our readers several numerical results worked out by Prof. Ewing. The eddy currents exert a demagnetising influence on the core, and cause the lines of force to crowd together at the surface of the iron, just as alternating currents in a thick conductor tend to confine themselves to the outer conducting layers. The magnitude of this effect is quite startling when the iron plates are not finely laminated, as Prof. Ewing calculates that with plates two millimetres thick the density of the lines of force at the surface is 10 times as great as in the middle portions of the iron.

In this issue appears an important Paper by Dr. Hopkinson and Mr. F. Wilson on dynamo-electric machines. The Paper is full of valuable matter stated in a concise way, and, like all the work with which Dr. Hopkinson is connected, it merits the closest attention. It forms the completion of the well-known Paper on Dynamos, presented by the Brothers Hopkinson to the Royal Society in 1886. On that occasion the influence of the re-actions of the armature were not fully considered, and the present investigation has consisted in applying the law of the magnetic circuit, first put into practical shape by Kapp and Hopkinson, to the local circuits in the neighbourhood of the armature core. The verification of this law has been carried out in a highly successful manner, with the result that the cross magnetisation caused by the currents in the armature is exhibited in a much clearer light than has hitherto been possible.

The committee of experts of the Crystal Palace, having no funds worth mentioning at their disposal, have issued a circular to exhibitors, signifying their willingness to witness any approved tests or experiments which they (the exhibitors) care to make. The committee will, we understand, invite the jury, who apparently have no voice in the matter, to consider these tests, with the view of making their awards. In order, we suppose, that the jury may have a quiet time, they are summoned on April 9th, when they will be undisturbed by sightseers who will be at the Boat Race. The first meeting of the jury was held simultaneously with, and within a few yards of, Herr Joachim's recital. Fortunately, this sort of thing cannot detract from the splendid success of the Exhibition.

When we first heard that the City of London Electric Lighting Company were going to adopt the transformer sub-station system, it occurred to us that there might be some difficulty in finding suitable sites; but difficulties are only made to be overcome. The churches of St. Bene't Sherehog and St. Nicholas Acons, both victims to the Great Fire, have churchyards, and these churchyards have vaults, and vaults are just the very thing for transformer sub-stations. Although the churches no longer exist, the rector and churchwardens, like the King, never die. Hence they have petitioned, as chronicled in another column, to be allowed to rent portions of the churchyards to the City of London Electric Lighting Company for the purpose of constructing transformer sub-stations therein.

Tanning by Electricity.—An electric tannery has been started at Verviers (Belgium).

The General Electric Power and Traction Company.—We understand that Mr. Robert Macpherson, late general manager to the Company, has resigned his position.

Toynbee Hall.—The next of the Science Conferences will be held on Wednesday, April 13th, when a Paper will be read on "Electrical Installations," by Mr. Reginald J. Jones.

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Storage Batteries for Telegraph Purposes.—At the Vienna central telegraph office there are at present 4,000 Daniell and 600 Meidinger cells in use, and it is proposed to replace them all by a battery of storage cells.

The Telephone at Cassel.—An impatient subscriber to the Cassel telephone exchange, who was moved by telephonic dilatoriness to send the epithet "sluggard" along the wires, has been condemned to pay a fine of £1 and costs.

University College, Bristol.—Courses on civil engineering, mining engineering and electrical engineering will be held during the third term, commencing April 26th. Further particulars will be found in our advertisement columns.

Copper in Madagascar.—It is announced that several rich copper deposits have recently been discovered in Madagascar. It is further reported that the new veins are so advantageously placed for shipping that at present prices it would pay well to work them.

Athens.—At the close of 1892 the lamps connected on to the Athens Electric Light Company's mains comprised 94 arcs and 4,164 incandescents. Current is supplied for motors to seven printing shops, the National Bank, and two other establishments.

The Metropolitan Electric Railway Schemes.—The five following lords have been named to join with the Select Committee of the House of Commons appointed to consider the Metropolitan Electric Railway schemes, viz., Lord Lauderdale, Lord Strafford, Lord Barrington, Lord Thring, and Lord Kelvin.

Industrial Applications of Electricity.—In May the Minister of Agriculture will open in Paris an International Exhibition connected with the alcohol trade. An entire section is to be devoted to electricity applied to brewing and similar purposes. The various electrical processes for rectifying spirit, and ageing wine and beer, &c., will be shown in operation.

Interurban Telephony.—Telephonic communication between Exeter and Plymouth was established this week by the Western Counties and South Wales Telephone Company. At the same time the intermediate towns were put into communication with these large centres. On Tuesday last the National Telephone Company opened the Belfast-Dublin line.

Coast Communications.—Sir Edward Birkbeck has added to his resolution with regard to coast communications, which has the first place for Tuesday, 26th inst., words declaring in favour of the appointment of a Royal Commission to consider the question of connecting certain lightships and outlying rock lighthouses with the shore by means of cable communication.

Siemens and Halske Telephone Cable.—According to the *Elektrotechnische Zeitschrift* Siemens and Halske are now turning out a lead-covered telephone cable for the Bavarian Government on the Fortin-Hermann plan, the dielectric being air. The insulation resistance is 100 megohms per kilometre at 15°C., and the electrostatic capacity is 0·08 to 0·09 microfarad per kilometre.

Personal.—Mr. J. F. C. Snell, has been appointed engineer to the Albert Electric Lighting Company. Mr. Snell was for several years with Messrs. Crompton and Co. as one of their assistant engineers on central-station contracts at home and abroad, and has been acting for the last few months as electrical inspector to the Directors of the Crystal Palace.

Electric Traction at Gera.—The electric tramway laid down by the Allgemeine Elektricitäts Gesellschaft is now in operation. An overhead wire is used as on the same Company's line at Halle. Fourteen cars are running, and when the traffic requires it each of these can take another in tow. The heavy grades (1 in 20 and 1 in 23) are easily mounted, and the line is becoming very popular with the inhabitants.

Milan.—We learn from *L'Elettricita* that the Municipal Council of Milan is examining several proposals for lighting the town, the contract with the Edison Company being about to terminate. It is said that this Company is prepared to reduce their charges both for public and private lamps, but that an offer has been received from Berlin, the terms of which are lower than those last named by the Edison Company.

Electric Traction in Ceylon.—It is, says *Indian Engineering*, proposed to construct an electric railway from Nanuoya to Nuwara Eliza; power will be obtained from a waterfall. The line is as nearly as possible four miles long, and the rise in elevation is about 900ft., giving a uniform gradient of 1 in 23. By lengthening the line to six miles, however, rounding some of the mountain valleys, a grade could be obtained workable after the ordinary fashion.

The Lighting of the Frankfort Exhibition.—The number of arc lamps employed in lighting the Frankfort Exhibition amounted to 880, with 15,740 incandescents. Inside the Exhibition 10 tons of bare copper and 20 tons of cables were laid down. In connection with the Palmgarten installation, 88 tons of bare copper and 20 tons of cable were used. In the Offenbach transmission 8 tons of bare copper, and in the Lauffen transmission 60 tons of bare copper were used.

Copper.—The statistical position of copper, according to Messrs. H. R. Merton and Co.'s monthly report for February, shows that the stocks in England and France and afloat thereto are smaller than they have been for the last three years. The stocks are now 54,311 tons, as against 56,781 tons on February 29th. While the supplies amounted to 8,335 tons during March, the deliveries were 10,805 tons, thus accounting for the reduction in stocks. At this time last year the stocks were 60,253 tons, and on March 31, 1890, as much as 91,938 tons.

A Long-lived 32-c.p. Lamp.—Mr. H. J. Wells, superintendent of the Osceola Light Company, Osceola, Pa., reports, says the *Electrical World*, that a Sawyer-Man lamp on one of the circuits of that Company has just closed a remarkable record. The lamp in question was constructed for an E.M.F. of 110 volts, and was run as nearly as possible at that voltage. Its normal brilliancy was 32 c.p. The lamp was placed in circuit February 22, 1889, and remained in service with an average use of 8½ hours per day until March 5, 1892.

Stealing Electricity.—According to the *Engineering Record*, a St. Louis Court has before it a novel case for adjudication. An electric light and power company brought suit for theft of electricity by bridging wires entering a store before the wires entered the meter. The defendant raised the point that electricity cannot be stolen, inasmuch as in order to constitute stealing there must be an *asportation*, a condition impossible in the case of electricity, which, not being in any wise under control, is therefore not the goods, property, or effects of anyone.

Maritzburg (Natal).—The Town Council have commissioned Mr. R. Lewis Cousins to investigate and report upon the water-power available in the vicinity of Maritzburg for light and power purposes. The most accessible and promising falls are the celebrated Howick Falls, reputed to be the second highest in the world, and the falls at Edendale and the Lower Umgeni. The Edendale Falls, which are some 60ft. high, are eight or nine miles from Maritzburg, and can furnish about 750 H.P. when the streams are moderately full. The Howick Falls are 364ft. high, and 11 miles from the town.

Glasgow.—We hear on reliable authority that the Contract Committee of the Town Council have decided to recommend the acceptance of Messrs. Latimer Clark, Muirhead and Co.'s electric lighting tender.—The Electric Lighting Sub-Committee of the Glasgow Gas Trust have agreed to recommend that, on and after May 31st next, the charge for electricity supplied from their central stations shall be reduced to 7d. per Board of Trade unit. The price charged hitherto, by both Messrs. Muir, Mavor, and Coulson, and by the Corporation has been 8d. per unit.

The Overland Trolley System in the States.—The rapidity of the introduction of the overhead trolley system has been extraordinary, says the *Electrical Engineer* of New York, and can only be accounted for on the supposition that it meets and

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fills one of the greatest wants of modern American communities. Of the 16 cities of the United States having over 200,000 inhabitants, 14, or 87 per cent., are equipped with electric roads. Of the 42 cities having between 50,000 and 200,000 inhabitants, 41, or 97½ per cent., have electric roads. Of the remaining 391 American cities that have a population over 8,000 we do not know of a score that have not an electric road or serious plans for establishing one.

Pole-Indicators.—*L'Electricien* is responsible for the following recipes for pole-indicator solutions. For placing inside a glass tube corked at either end and provided with adjustable electrodes:—50 grammes of glycerine, 3 grammes of saltpetre, 20 grammes of water, 0 5 gramme of phenol phtalein dissolved in 10 grammes of alcohol. The *negative* pole is surrounded on the passage of a current with a violet-red aureole. Paper cut into short strips may be used as pole-indicators if dipped into a bath composed of 250 grammes of saltpetre, dissolved in a litre of water (8¾oz. to 1 quart), then dried, and finally soaked in a solution of 5 to 6 grammes of phenol phtalein dissolved in alcohol. If the last treatment is replaced by any of the following, we get the results set forth:—

	Colouration.	Pole.
Rosolic acid (neutralised)	Violet ...	Negative
Methyl violet	Blue-green...	Positive
Tropælin OO, or orange No. 4 of Poirier	Bright red...	Positive
Orange No. 3. (These two have a Diphenylamine base)	Bright red...	Positive
Orange No. 1. or No. 2 (Naphtol base)	Red ...	Negative

Litmus paper can also be made use of as a pole-indicator.

Water Power for Electrical Purposes.—In reporting on a proposed new storage reservoir at Plymouth, the water engineer (Mr. Sandeman) states that one could be constructed at Burrator. Here one could be formed, with a capacity of 422 million gallons, for £96,000. The reservoir could be designed so that, when requisite, its storage capacity could be increased (at small cost) by 350 million gallons by raising the dams 10ft. higher, making the total storage capacity 800 million gallons. Dealing with the question of water power, Mr. Sandeman says, assuming the town to be in possession of storage capacity sufficient to ensure a daily supply of 6 million gallons, the energy available by utilising the fall from one reservoir to another would give a total gross H.P. of 464; and after deducting the friction in the pipes, turbines, &c., a net H.P. of 175. It should be remembered, observes the engineer, that this power is continuous through the 24 hours; and if it be found advisable at some future time to introduce into the town the system of supplying water-power at high pressure (600 or 700lb. per square inch), for the use of small traders and manufacturers in place of steam-power, the means of producing hydraulic power by day and electric light by night are here present.

Ascertaining Distances and Directions at Sea.—The necessity for some means of finding the direction and distance of another ship at sea, especially in fogs, gives much interest, says the *Engineer*, to the following method of measuring distances at sea, devised by Mr. H. P. Dowling, of Cardiff:—It consists essentially in the employment of apparatus for sending sound signals simultaneously through air and through the water; and apparatus for receiving and registering the sound so sent, so that the difference in time of arrival through both media may be used to indicate the distance. Duplicate sounds could be produced by the detonation of gunpowder, gun-cotton, or by double bells, double syrens, &c. The receiving apparatus would consist of pairs of similar vibrating diaphragms, one of each pair being situated in the sea, and the other in the air vertically over the first. The vibrations of these plates would be used to work an electric contact-breaker, and thus cause the sound-signals to automatically control a registering instrument. The registering apparatus would have a system of electro-magnets and armatures, actuating pencils pressing on the surface of a strip of moving paper. The clockwork would make marks at regular intervals on the paper. If these marks were made at intervals of 3·6 seconds, or fractions of that time, the distance could be read at a glance, in miles or fractions thereof. The interval of 3·6 seconds is arrived at on the assumption that sound travels 1,100ft. in air and 4,400ft. in water per second. One pair of receiving instruments would serve to determine distances in a line at right angles to the plane of the diaphragms; and four pairs would suffice to determine distances at all points of the compass.

Atmospheric Electricity.—In a communication recently made to the Académie des Sciences M. Ch. André states that the presence of negative electricity during fine weather is a rare phenomenon, hitherto considered accidental, and for which a special cause foreign to the most generally received theories of atmospheric electricity has been sought. Exner attributes it to the presence of dust electrified by friction with the earth. Palmieri, on the other hand, thinks that he has found negative electricity to be invariably accompanied by a downpour of rain somewhere in the vicinity, the clouds being below the horizon. M. Ch. André then gives three instances taken from records at the Lyons observatory which do not fit with either theory. The dust hypothesis will not do, since no dust was observed, and the wind (south) which prevailed is at Lyons unfavourable to the carriage of dust. The rain hypothesis is also rejected, since on at least one of the occasions (July 10, 1889) none fell in the large region included between the sea and the Alps. M. Ch. André is of opinion that the temporary negative dip of the curve which took place about midday on June 24 and September 25 (1885), and July 10 (1889), must be attributed to the remarkable atmospheric conditions which obtained on these three days in the neighbourhood of Lyons, viz. (1) abnormal vertical distribution of temperature, such that on September 15th the minimum at the top of the Puy-de-Dôme was 9°C. higher than that at Clermont-Ferrand; (2), an exceedingly great relative dryness of the atmosphere on June 24th, the minimum of the hygrometer, which occurred about the middle of the negative dip, was the minimum for the June, July, August quarter for the eight years 1883 1891. The appearance of negative electricity in fine weather seems to M. Ch. André to be merely an exaggeration of the daily dip in the positive curve.

The Electrical Trade Section.—In the Annual Report of the London Chamber of Commerce it is stated that five meetings of this Section and its Committee have taken place during the year 1891. The question of Overhead Wires and the Model Clauses of 1889 and 1890, for the protection of telephones, received special attention in the early part of the year, and representations on both of these questions were made to the Board of Trade. The views of the Section in regard to the desirability of the commercial element being represented on the Electrical Standards Committee were also placed before the same Department. In August the Section had a conference with the Directors of the Crystal Palace, with a view to arriving at some agreement with the Company as to the advisability of postponing the opening of the Electrical Exhibition which that Company had projected. One beneficial result of the Conference was that the Crystal Palace Company agreed to postpone the opening of the Exhibition until the 1st of January. Under the auspices of the Section, a visit was made to the Frankfort Exhibition in the month of September. The most important action of the Section, says the Report, has been the drawing up of a memorial to the Board of Trade on the question of Overhead Wires. This memorial was signed by every leading electrical firm throughout the United Kingdom; and while the Board of Trade had already declared its fixed intention not to permit the erection of overhead wires under any circumstances, the object of the memorial was somewhat anticipated before it was sent in to the Board of Trade, by the Department declaring, in a letter to a private firm, (see *The Electrician*, January 8, p. 241), that it had never absolutely forbidden the erection of Overhead Wires, though it believed that their use was accompanied by many serious disadvantages. Probably the very representative character of the memorial, which the Board of Trade had been acquainted with through the medium of the electrical papers before the Chamber had had time to fully complete the list of signatories, had a very great deal to do with the considerably-modified decision which the Board of Trade gave on the subject while the memorial was in course of completion.

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ELECTROMAGNETIC THEORY.—XXVII.

BY OLIVER HEAVISIDE.

(*Continued from page 537.*)

§ **130.** Returning to the theorem (147), or

$$\Sigma\, \mathrm{F}(\mathbf{N}) = \Sigma f, \quad . \quad . \quad . \quad . \quad . \quad . \quad (153)$$

let us take a few of the simplest cases that present themselves. Given any odd function F of **N**, the normal outwards from a closed surface over which the summation on the left side extends, we convert it to an equivalent summation throughout the enclosed region by making f, the quantity summed, be the value of $\Sigma\, \mathrm{F}(\mathbf{N})$ for the surface of the element of volume. This last is most conveniently a unit cube, so that

$$f = \nabla_1 \mathrm{F}(\mathbf{i}) + \nabla_2 \mathrm{F}(\mathbf{j}) + \nabla_3 \mathrm{F}(\mathbf{k}), \quad . \quad . \quad . \quad (154)$$

as in (148).

(*a*). The simplest case of all is $\mathrm{F}(\mathbf{N}) = \mathbf{N}$ itself. Then, by (154), or by considering that the vector normals to the six faces of a cube balance one another in pairs, we have

$$\Sigma\, \mathbf{N} = 0, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (155)$$

expressing that a closed surface has no resultant orientation; or, that a normal pull applied to every part of a closed surface, of uniform amount per unit area, has no resultant.

(*b*). If we multiply by p, any scalar function of position, we have the same case again if p be constant. When negative, it makes a well-known elementary hydrostatic result. But when p is not constant, then, by (154),

$$f = \nabla_1 \mathbf{i}p + \nabla_2 \mathbf{j}p + \nabla_3 \mathbf{k}p = \nabla p, \quad . \quad . \quad . \quad (156)$$

so that we have

$$\Sigma\, \mathbf{N}p = \Sigma\, \nabla p. \quad . \quad . \quad . \quad . \quad . \quad . \quad (157)$$

These are, of course, vector summations. The sum of the surface tractions equals the sum of the bodily forces ∇p arising from the space-variation of the internal tension. Take p negative to indicate pressure.

(*c*). Take $\mathrm{F}(\mathbf{N}) = \mathbf{ND}$, where **D** is a vector function of position. This gives the most valuable theorem of divergence,

$$\Sigma\, \mathbf{ND} = \Sigma\, \nabla\mathbf{D} = \Sigma\, \mathrm{div}\mathbf{D}, \quad . \quad . \quad . \quad (158)$$

already discussed.

(*d*). Take $\mathrm{F}(\mathbf{N}) = \mathbf{ND}\mathrm{P}$, where P is a scalar. Here, by (154), or by (158), we shall find

$$\Sigma\, \mathbf{ND}\mathrm{P} = \Sigma\, \nabla(\mathbf{D}\mathrm{P}). \quad . \quad . \quad . \quad . \quad . \quad (159)$$

Here ∇ has to differentiate both **D** and P, thus,

$$\nabla.\mathbf{D}\mathrm{P} = \nabla\mathbf{D}.\mathrm{P} + \mathbf{D}\nabla\mathrm{P}, \quad . \quad . \quad . \quad . \quad (160)$$

so that the previous equation may be written

$$\Sigma\, \mathbf{ND}\mathrm{P} = \Sigma\, \mathrm{P}\mathrm{div}\mathbf{D} + \Sigma\, \mathbf{D}\nabla\mathrm{P}, \quad . \quad . \quad . \quad (161)$$

which is a form of Green's Theorem relating to electrostatic energy. **D** may be the displacement in one system of electrification and P the potential in another. The quantity $-\Sigma\, \mathbf{D}\nabla\mathrm{P}$ is their mutual energy; and this is, by (161), equivalently expressed by the sum of products of every charge in one system into the potential due to the other.

(*e*). Take $\mathrm{F}(\mathbf{N}) = \mathrm{V}\mathbf{NH}$. Then, by (154),

$$f = \nabla_1 \mathrm{V}\mathbf{i}\mathbf{H} + \nabla_2 \mathrm{V}\mathbf{j}\mathbf{H} + \nabla_3 \mathrm{V}\mathbf{k}\mathbf{H}.$$

But here we may shift the ∇'s to the other side of the V's, because they are scalars; this produces

$$f = \mathrm{V}\nabla\mathbf{H},$$

so that we have

$$\Sigma\, \mathrm{V}\mathbf{NH} = \Sigma\, \mathrm{V}\nabla\mathbf{H} = \Sigma\, \mathrm{curl}\, \mathbf{H}. \quad . \quad . \quad . \quad (162)$$

The interpretation may be more readily perceived by reversing the direction of the normal. Take $\mathbf{N} = -\mathbf{n}$, so that **n** is the normal drawn inward from the boundary. Then

$$\Sigma\, \mathrm{curl}\, \mathbf{H} + \Sigma\, \mathrm{V}\mathbf{n}\mathbf{H} = 0. \quad . \quad . \quad . \quad . \quad (163)$$

If **H** be magnetic force, curl **H** is the electric current-density in the region. Now $\mathrm{V}\mathbf{n}\mathbf{H}$ is the surface equivalent of the bodily curl **H**. Ignore altogether the magnetic force outside the region, if there be any. Then the circuitation of **H** gives the current through a circuit. Applied to elementary circuits wholly within the region, the result is curl **H**. But at the boundary, where **H** suddenly ceases, there is a surface-current as well. To find its expression, apply the process of circuitation to a circuit consisting of two parallel lines of unit length, infinitely close together, but on opposite sides of the boundary, joined by infinitely short cross-pieces. Only the unit line inside the region contributes anything to the circuitation; and by taking it to coincide with **H**, so as to make the circuitation a maximum, we find that $\mathrm{V}\mathbf{n}\mathbf{H}$ represents the surface-density of current. So, if **J** be current, we have, by (163), $\Sigma\, \mathbf{J} = 0$ for any region, by itself. The surface-distribution and the volume-distribution of current are complementary; that is, they are properly joined together to make up a circuital distribution. Thus,

$$\mathbf{n}\mathrm{V}\nabla\mathbf{H} = -\nabla\mathrm{V}\mathbf{n}\mathbf{H}, \quad . \quad . \quad . \quad . \quad (164)$$

where on the left side we have the divergence (at the surface) of the internal current, and on the right the equal convergence of the surface-current.

§ **131.** Next, take a few examples of the extended Theorem of Version (152), viz.:—

$$\Sigma\, \mathrm{F}(\mathbf{T}) = \Sigma f, \quad . \quad . \quad . \quad . \quad . \quad (165)$$

where now, on the left side, we have the circuital summation of an odd function of **T**, and on the right an equivalent surface-summation, whose elementary part f is the value of $\mathrm{F}(\mathbf{T})$ for the circuit bounding the element of surface.

Taking three elements of surface to be unit squares, whose normals are **i**, **j**, **k**, we readily see that the corresponding f's are

$$\nabla_2 \mathrm{F}(\mathbf{k}) - \nabla_3 \mathrm{F}(\mathbf{j}), \quad \nabla_3 \mathrm{F}(\mathbf{i}) - \nabla_1 \mathrm{F}(\mathbf{k}), \quad \nabla_1 \mathrm{F}(\mathbf{j}) - \nabla_2 \mathrm{F}(\mathbf{i}). \quad (166)$$

By means of these we can see the special form assumed by f in any case.

(*a*). Thus, take $\mathrm{F}(\mathbf{T}) = \mathbf{T}$ itself, the unit tangent. Then we have

$$\Sigma\, \mathbf{T} = 0, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (167)$$

merely expressing the fundamental property of adding vectors, that the sum of any vectors forming, when put end to end, a circuit, is zero.

(*b*). Take $\mathrm{F}(\mathbf{T}) = \mathbf{T}\mathrm{P}$, where P is a scalar function of position. Then, with normal **i**, we have, by the first of (166),

$$f = \nabla_2 \mathbf{k}\mathrm{P} - \nabla_3 \mathbf{j}\mathrm{P} = \mathrm{V}\mathbf{i}\nabla.\mathrm{P}; \quad . \quad . \quad (168)$$

so, writing **N** for **i**, we obtain

$$\Sigma\, \mathbf{T}\mathrm{P} = \Sigma\, \mathrm{V}\mathbf{N}\nabla.\mathrm{P} = \Sigma\, \mathrm{V}\mathbf{N}\nabla\mathrm{P}. \quad . \quad . \quad . \quad (169)$$

The quantity summed over the surface is, therefore, the surface representative of the curl of $\nabla\mathrm{P}$. This has no volume representative, its value being then zero.

(*c*). Take $\mathrm{F}(\mathbf{T}) = \mathbf{TH}$. Here, with normal **i** to the element of surface, we have

$$f = \nabla_2 \mathbf{k}\mathbf{H} - \nabla_3 \mathbf{j}\mathbf{H} = \nabla_2 \mathrm{H}_3 - \nabla_3 \mathrm{H}_2 = \mathbf{i}\mathrm{V}\nabla\mathbf{H},$$

by (149). Therefore, putting **N** for **i**,

$$\Sigma\, \mathbf{TH} = \Sigma\, \mathbf{N}\mathrm{V}\nabla\mathbf{H} = \Sigma\, \mathbf{N}\, \mathrm{curl}\, \mathbf{H} \quad . \quad . \quad (170)$$

the Version Theorem again. But observe that, by the transformation (164), we may also write it

$$\Sigma\, \mathbf{TH} = \Sigma\, \mathbf{N}\mathrm{V}\nabla.\mathbf{H}, \quad . \quad . \quad . \quad . \quad (171)$$

similarly to (169), in which the operand is a scalar. This is mnemonically useful, but (170) is more practically useful.

(*d*). Take $\mathrm{F}(\mathbf{T}) = \mathrm{V}\mathbf{TH}$. Here, with normal **i**, the first of (166) gives

$$f = \nabla_2 \mathrm{V}\mathbf{k}\mathbf{H} - \nabla_3 \mathrm{V}\mathbf{j}\mathbf{H} = \mathrm{V}\,(\mathbf{k}\nabla_2 - \mathbf{j}\nabla_3)\mathbf{H}.$$

But here we have $\mathbf{k}\nabla_2 - \mathbf{j}\nabla_3 = \mathrm{V}\mathbf{i}\nabla$,

so that $f = \mathrm{V}\,(\mathrm{V}\mathbf{i}\nabla)\mathbf{H}$;

and therefore, generally, putting **N** for **i**,

$$\Sigma\, \mathrm{V}\mathbf{TH} = \Sigma\, \mathrm{V}\,(\mathrm{V}\mathbf{N}\nabla)\,\mathbf{H}. \quad . \quad . \quad . \quad (172)$$

(*e*). Let the quantity in the circuital summation be a vector of length P (a scalar function of position) drawn perpendi-

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cularly to the plane of **T** and **N**. That is,

$$F(\mathbf{T}) = (V\mathbf{TN})P.$$

We then find, taking $\mathbf{N} = \mathbf{i}$, and using the first of (166),

$$f = \nabla_2 V\mathbf{ki} \,.\, P - \nabla_3 V\mathbf{ji} \,.\, P = (\mathbf{j}\nabla_2 + \mathbf{k}\nabla_3)P = \nabla P - \mathbf{i}\,(\mathbf{i}\nabla)\,P.$$

In general, therefore,

$$\Sigma\, V\mathbf{TN} \,.\, P = \Sigma\,(\nabla P - \mathbf{N} \,.\, \mathbf{N}\nabla P) = \Sigma\,\nabla_s P = \Sigma\, V\,(V\mathbf{N}\nabla)\mathbf{N}.P \quad . \quad (173)$$

The element of the surface-summation is $\nabla_s P$, meaning the slope of P on the surface itself, disregarding any variation it may have out of the surface. The last form of (173) involves the transformation formula (52).

Observe that in all the above examples,

$$\Sigma\, F(\mathbf{N}) = \Sigma\, F(\nabla), \quad . \quad . \quad . \quad . \quad . \quad . \quad (174)$$

when we pass from a closed surface to the enclosed region; and that

$$\Sigma\, F(\mathbf{T}) = \Sigma\, F(V\mathbf{N}\nabla), \quad . \quad . \quad . \quad . \quad (175)$$

when we pass from a circuit to the surface it bounds. Thus, **N** becomes ∇, and **T** becomes $V\mathbf{N}\nabla$. But I cannot recommend anyone to be satisfied with such condensed symbolism alone. It is much more instructive to go more into detail, as in the above examples, and see how the transformations occur, bearing in mind the elementary reasoning upon which the passage from one kind of summation to another is based (§§ 128, 129).

§ 132. The following examples relate principally to the modifications introduced by the differentiating functions of ∇.

(*a*). We have, by the parallelepipedal property,

$$\mathbf{N}V\nabla\mathbf{E} = \nabla V\mathbf{E}\mathbf{N} = \mathbf{E}V\mathbf{N}\nabla, \quad . \quad . \quad . \quad (176)$$

when ∇ is a common vector. The equalities remain true when ∇ is vex, provided we consistently employ the differentiating power in the three forms. Thus, the first form, expressing the **N** component of curl **E**, is not open to misconception. But in the second form, expressing the divergence of $V\mathbf{E}\mathbf{N}$, since **N** follows ∇, we must understand that **N** is supposed to remain constant. In the third form, again, the operand **E** precedes the differentiator. We must either, then, assume that ∇ acts backwards, or else, which is preferable, change the third form to $V\mathbf{N}\nabla.\mathbf{E}$, the scalar product of $V\mathbf{N}\nabla$ and **E**; or $(V\mathbf{N}\nabla)\,\mathbf{E}$, if that be plainer.

(*b*). Suppose, however, that both vectors in the vector product are variable. Thus, required the divergence of $V\mathbf{E}\mathbf{H}$, expanded vectorially. We have

$$\nabla V\mathbf{E}\mathbf{H} = \mathbf{E}V\mathbf{H}\nabla - \mathbf{H}V\nabla\mathbf{E}, \quad . \quad . \quad . \quad (177)$$

where the first form alone is entirely unambiguous. But we may use either of the others, provided the differentiating power of ∇ is made to act on both **E** and **H**. But if we keep to the plainer and more usual convention that the operand is to follow the operator, then the third form, in which **E** alone is differentiated, gives one part of the result, whilst the second form, or rather, its equivalent $-\mathbf{E}V\nabla\mathbf{H}$, wherein **H** alone is differentiated, gives the rest. So we have, complete, and without ambiguity,

$$\operatorname{div} V\mathbf{E}\mathbf{H} = \mathbf{H}\operatorname{curl}\mathbf{E} - \mathbf{E}\operatorname{curl}\mathbf{H}, \quad . \quad . \quad . \quad (178)$$

a very important transformation. It is concerned in the deduction of the equation of activity from the two circuital laws of electromagnetism.

(*c*). In these circuital laws we have also to consider the curl of a vector product, viz., the curl of the motional electric force in one law, and the curl of the motional magnetic force in the other. Taking the former, we have

$$\operatorname{curl} V\mathbf{q}\mathbf{B} = V\nabla V\mathbf{q}\mathbf{B}, \quad . \quad . \quad . \quad . \quad (179)$$

where **B** is the induction and **q** the velocity of the medium supporting it. Apply the elementary transformation (52) to (179). It gives

$$V\nabla V\mathbf{q}\mathbf{B} = \mathbf{q}.\nabla\mathbf{B} - \mathbf{B}\cdot\nabla\mathbf{q}, \quad . \quad . \quad . \quad (180)$$

when ∇ is a mere vector. But on the left side both **q** and **B** have to be differentiated; therefore the same is true in both terms on the right side. This gives

$$V\nabla V\mathbf{q}\mathbf{B} = \mathbf{q}\operatorname{div}\mathbf{B} + \mathbf{B}\nabla.\mathbf{q} - \mathbf{B}\operatorname{div}\mathbf{q} - \mathbf{q}\nabla.\mathbf{B}, \quad . \quad . \quad . \quad (181)$$

without ambiguity or need of reservation. That is to say, as in the $\mathbf{q}.\nabla\mathbf{B}$ of (180) both **q** and **B** have to be differentiated, we get $\mathbf{q}\operatorname{div}\mathbf{B}$ when **B** alone, and $\mathbf{B}\nabla.\mathbf{q}$ when **q** alone is differentiated. Similarly for the other term in (180).

Or we might write ∇_q when **q** alone, and ∇_B when **B** alone suffers differentiation. Then, fully,

$$V\nabla V\mathbf{q}\mathbf{B} = V\nabla_q V\mathbf{q}\mathbf{B} + V\nabla_B V\mathbf{q}\mathbf{B}, \quad . \quad . \quad (182)$$

$$V\nabla_q V\mathbf{q}\mathbf{B} = \mathbf{B}\nabla.\mathbf{q} - \mathbf{B}\operatorname{div}\mathbf{q}, \quad . \quad . \quad . \quad . \quad (183)$$

$$V\nabla_B V\mathbf{q}\mathbf{B} = \mathbf{q}\operatorname{div}\mathbf{B} - \mathbf{q}\nabla.\mathbf{B}. \quad . \quad . \quad . \quad . \quad (184)$$

Here the sum of (183) and (184) gives (181). The meaning of $\mathbf{B}\nabla$ and $\mathbf{q}\nabla$ has been already explained.

(*d*). Equation (181) may be applied to the circuital laws. Take the second, for example, in the form (4), § 66,

$$-\operatorname{curl}(\mathbf{E} - \mathbf{e}_0) = \mathbf{K} + \dot{\mathbf{B}} + \mathbf{w}\sigma - \operatorname{curl}\dot{\mathbf{B}}V\mathbf{q}\mathbf{B}, \quad . \quad (185)$$

and suppose that $\mathbf{w} = \mathbf{q}$, or that sources move with the medium. Then, by (181), we cancel the convective term $\mathbf{w}\sigma$. Further, we have $\dot{\mathbf{B}} + \mathbf{q}\nabla.\mathbf{B} = \delta\mathbf{B}/\delta t$, by (127), § 122, so that (185) becomes

$$-\operatorname{curl}(\mathbf{E} - \mathbf{e}_0) = \mathbf{K} + \delta\mathbf{B}/\delta t + \mathbf{B}\operatorname{div}\mathbf{q} - \mathbf{B}\nabla.\mathbf{q}, \quad . \quad (186)$$

and the corresponding form of the first law (equation (3), § 66), is

$$\operatorname{curl}(\mathbf{H} - \mathbf{h}_0) = \mathbf{C} + \delta\mathbf{D}/\delta t + \mathbf{D}\operatorname{div}\mathbf{q} - \mathbf{D}\nabla.\mathbf{q}. \quad . \quad (187)$$

The time-variations refer to the same (moving) portion of the medium now. But if we wish to indicate the movement of electrification, &c., through the medium, that is, have relative motion $\mathbf{u} - \mathbf{q}$ of ρ (and $\mathbf{w} - \mathbf{q}$ of σ) with respect to the ether, then to the right side of (187) add the term $(\mathbf{u} - \mathbf{q})\rho$, and to the right ride of (186) add $(\mathbf{w} - \mathbf{q})\sigma$.

It is desirable to preserve the velocities **u** and **w**, or else the relative velocities, as well as the velocity **q** of the medium, in order to facilitate the construction and comprehension of problems relating to electromagnetic waves, which, although abstract and far removed from practice, are of a sufficiently simple nature to enable one to follow the course of events.

(*e*). We have already had the divergence of the product of a scalar and vector under consideration. Now examine its curl. Thus,

$$\begin{aligned}\operatorname{curl}\mathbf{D}P &= V\nabla(\mathbf{D}P)\\ &= V\nabla\mathbf{D}.P - V\mathbf{D}\nabla.P\\ &= P\operatorname{curl}\mathbf{D} - V\mathbf{D}\nabla P. \quad . \quad . \quad . \quad (188)\end{aligned}$$

Here ∇ can only make a vector product with **D**, because P is scalar. On the other hand, both P and **D** suffer differentiation. So in the second line we have ∇ both before and after **D**.

(*f*). The divergence of the curl of any vector is zero. That is, $\operatorname{div}\operatorname{curl}\mathbf{H} = 0$, or $\nabla V\nabla\mathbf{H} = 0$. . . (189)

If ∇ here were a real vector (189) would mean that the volume of a parallelepiped vanishes when two edges coincide.

(*g*). A somewhat similar case is presented by the vanishing of the curl of a polar force. Thus,

$$\operatorname{curl}\nabla P = 0, \quad \text{or} \quad V\nabla\cdot\nabla P = 0. \quad . \quad . \quad . \quad (190)$$

Of course $V_{\nabla\nabla}$ is zero. But the scalar product $\nabla\nabla$, or ∇^2, is the Laplacean operator,

$$\nabla^2 = \nabla_1^2 + \nabla_2^2 + \nabla_3^2, \quad . \quad . \quad . \quad . \quad (191)$$

which occurs frequently.

(*h*). Let the operation curl be done twice on a vector. Thus,

$$\begin{aligned}(\operatorname{curl})^2\mathbf{A} &= V\nabla V\nabla\mathbf{A}\\ &= \nabla\cdot\nabla\mathbf{A} - \nabla^2\mathbf{A}, \quad . \quad . \quad . \quad (192)\end{aligned}$$

by the transforming formula (52). Or

$$\nabla^2\mathbf{A} = \nabla\operatorname{div}\mathbf{A} - \operatorname{curl}^2\mathbf{A}. \quad . \quad . \quad . \quad (193)$$

Thus there are two principal forms. If the vector **A** has no curl, then $\nabla^2\mathbf{A}$ is the slope of its divergence. If, on the other hand, it has no divergence, then ∇^2 has the same effect exactly as taking the curl twice.

In the case of the operand being a scalar, then we have

$$\nabla^2 P = \operatorname{div}\nabla P, \quad . \quad . \quad . \quad . \quad (194)$$

the divergence of the slope of the scalar.

(To be continued.)

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ON THE HEAT PRODUCED BY EDDY CURRENTS IN AN IRON PLATE EXPOSED TO AN ALTERNATING MAGNETIC FIELD.

BY PROF. J. J. THOMSON, M.A., F.R.S.

In my paper "On the Discharge of Electricity through Exhausted Tubes without Electrodes" (*Phil. Mag.*, Nov., 1891, p. 459), I had occasion to investigate the absorption of energy by a piece of iron placed near a primary coil through which the rapidly alternating currents produced by the discharge of a Leyden jar were passing. In the following paper I apply this investigation to determine the rate of heat-production by eddy currents in the iron plates of an ordinary transformer, as I understand from Prof. Ewing that this question is, at present, of some interest to electrical engineers. The case I shall consider is that of an iron plate AB CD in a transformer, the plate being surrounded by wire through which an alternating current is passing.

We shall take as the plane of yz the plane parallel to the sides AB CD of the plate, and, midway between them, we shall suppose that the coils of wire are parallel to the axis of y, so that the magnetic force will be parallel to z. Let the magnetic force just outside the plate be $\mathbf{H}_0 \cos pt$. Inside the plate the magnetic force satisfies the differential equation,

$$\frac{d^2\mathbf{H}}{dx^2} = \frac{4\pi\mu}{\sigma}\frac{d\mathbf{H}}{dt} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where μ is the magnetic permeability of the plate and σ its specific resistance. Since $\mathbf{H}$ varies as the real part of ϵ^{ipt} where ϵ is the base of the Napierian logarithms, and $i = \sqrt{-1}$, equation (1) may be written

$$\frac{d^2\mathbf{H}}{dx^2} = \frac{4\pi\mu ip}{\sigma}\mathbf{H},$$
$$= m^2(1+i)^2\mathbf{H},$$

where $m^2 = 2\pi\mu p/\sigma$.

The solution of this equation is

$$\mathbf{H} = \{A\,\epsilon^{m(1+i)x} + B\,\epsilon^{-m(1+i)x}\}\,\epsilon^{ipt}.$$

Since the distribution of magnetic force is symmetrical with respect to the plane of yz we may write this equation in the form

$$\mathbf{H} = A'\{\epsilon^{mx}\cos(pt+mx) + \epsilon^{-mx}\cos(pt-mx)\}$$
$$+ B'\{\epsilon^{mx}\sin(pt+mx) + \epsilon^{-mx}\sin(pt-mx)\} \quad . \quad (2).$$

We can determine A' and B' from the condition that when $x=h$, where $2h$ is the thickness of the plate, $\mathbf{H} = \mathbf{H}_0\cos pt$.

Hence, putting $x=h$, and equating the coefficient of $\cos pt$ on the right-hand side of equation (2) to $\mathbf{H}_0$ and the coefficient of $\sin pt$ to zero, we have

$$\mathbf{H}_0 = A'(\epsilon^{mh}+\epsilon^{-mh})\cos mh + B'(\epsilon^{mh}-\epsilon^{-mh})\sin mh$$
$$0 = A'(\epsilon^{mh}-\epsilon^{-mh})\sin mh - B'(\epsilon^{mh}+\epsilon^{-mh})\cos mh.$$

Solving these equations we find

$$\left.\begin{aligned} A' &= \mathbf{H}_0\frac{(\epsilon^{mh}+\epsilon^{-mh})\cos mh}{\epsilon^{2mh}+\epsilon^{-2mh}+2\cos 2mh} \\ B' &= \mathbf{H}_0\frac{(\epsilon^{mh}-\epsilon^{-mh})\sin mh}{\epsilon^{2mh}+\epsilon^{-2mh}+2\cos 2mh} \end{aligned}\right\} \quad . \quad . \quad . \quad (3).$$

Substituting these values for A' and B' we find

$$\mathbf{H} = \mathbf{H}_0\left\{\frac{\epsilon^{2mx}+\epsilon^{-2mx}+2\cos 2mx}{\epsilon^{2mh}+\epsilon^{-2mh}+2\cos 2mh}\right\}^{\frac{1}{2}}\cos(pt+\epsilon)$$

Where

$$\tan\epsilon = \frac{\sinh m(h+x)\sin m(x-h) - \sinh m(h-x)\sin m(h+x)}{\cosh m(h+x)\cos m(x-h) + \cosh m(h-x)\cos m(x+h)}$$

where $\sinh\theta$ is written for $\frac{1}{2}(\epsilon^{\theta}-\epsilon^{-\theta})$, and $\cosh\theta$ for $\frac{1}{2}(\epsilon^{\theta}+\epsilon^{-\theta})$.

If v is the intensity of the current parallel to the axis of y, then

$$4\pi v = \frac{d\mathbf{H}}{dx}$$

$$= A'm\sqrt{2}\{\epsilon^{mx}\cos(mx+pt+\pi/4) - \epsilon^{-mx}\cos(pt-mx+\pi/4)\}$$
$$+ B'm\sqrt{2}\{\epsilon^{mx}\sin(mx+pt+\pi/4)$$
$$- \epsilon^{-mx}\sin(pt-mx+\pi/4)\} \quad . \quad (4)$$

The rate of heat-production per unit area of the plate is the mean value with respect to the time of

$$\int_{-h}^{+h}\sigma v^2 dx$$

Now the mean value with respect to the time of v^2 is by (4) equal to

$$\frac{m^2}{16\pi^2}(A'^2+B'^2)\{\epsilon^{2mx}+\epsilon^{-2m}-2\cos 2mx\}$$

Hence the mean value of

$$\int_{h}^{+h}\sigma v^2 dx = \frac{\sigma m}{16\pi^2}(A'^2+B'^2)\{\epsilon^{2mh}-\epsilon^{-2mh}-2\sin 2mh\}$$

Substituting the values we have previously given for A' and B', the rate of heat-production W is found to be equal to

$$\frac{\sigma m}{16\pi^2}\mathbf{H}_0^2\frac{\{\epsilon^{2mh}-\epsilon^{-2mh}-2\sin 2mh\}}{\epsilon^{2mh}+\epsilon^{-2mh}+2\cos 2mh} \quad . \quad . \quad (5)$$

For some purposes it is more convenient to express the rate of heat-production in terms of the average magnetic induction across the plate than in terms of the magnetic force outside the iron. If $\mathbf{B}$ is the maximum value of the mean induction across the plate, then since we have

$$\mathbf{B}\cos(pt+\alpha) = \frac{\mu}{2h}\int_{-h}^{+h}\mathbf{H}\,dx,$$

we find by substituting the value we have previously found for $\mathbf{H}$ that

$$\mathbf{B}^2 = \frac{\mu^2\mathbf{H}_0^2}{2h^2m^2}\frac{(\epsilon^{2mh}+\epsilon^{-2mh}-2\cos 2mh)}{\epsilon^{2mh}+\epsilon^{-2mh}+2\cos 2mh}.$$

Thus the rate of heat-production, expressed in terms of $\mathbf{B}$, is

$$\frac{h^2\sigma m^3\mathbf{B}^2}{8\pi^2\mu}\frac{(\epsilon^{2mh}-\epsilon^{-2mh}-2\sin 2mh)}{\epsilon^{2mh}+\epsilon^{-2mh}-2\cos 2mh} \quad . \quad . \quad (6).$$

When mh is very large we see from equation (3) that

$$A' = \mathbf{H}_0\epsilon^{-mh}\cos mh$$
$$B' = \mathbf{H}_0\epsilon^{-mh}\sin mh.$$

Hence, by (2),

$$\mathbf{H} = \mathbf{H}_0\{\epsilon^{-m(h-x)}\cos\{m(x-h)+pt\}$$
$$+ \epsilon^{-m(h+x)}\cos\{m(h+x)+pt\}\}.$$

Thus the magnetic force does not penetrate into the iron to a depth greater than a small multiple of $1/m$.

Let us now return to equation (5). We see that when mh is large, W the rate of heat-production is given by the equation

$$W = \frac{\sigma m}{16\pi^2}\mathbf{H}_0^2$$
$$= \sqrt{\frac{2\pi\mu p\sigma}{16\pi^2}}\mathbf{H}_0^2$$

In this case the work lost by eddy currents is independent of the thickness of the plate, which we can easily see must be the case, since the magnetic force and the currents are confined merely to a thin skin, and that by far the greater part of the iron of the plate is free from magnetic force and electric currents. When the plate is so thin that mh is small then equation (5) becomes

$$W = \frac{1}{3\pi^2}\mathbf{H}_0^2\sqrt{2\pi\mu p\sigma}\,m^3h^3$$
$$= \frac{1}{3\sigma}\mathbf{H}_0^2\mu^2p^2h^3.$$

Thus the heating effect in the plate increases as the cube of the thickness, the loss of energy from this cause is therefore greatly diminished when the thickness of the plate is diminished. If a slab of iron of given thickness is divided up into laminæ then, since the loss of energy in each lamina is proportional to h^3,

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while the number of laminæ is proportional to $1/h$, the loss by heating in the whole slab will be proportional to h^2. In other words, when a slab of iron of given thickness is divided into thin laminæ the loss of energy by eddy currents is *inversely proportional to the square of the number of laminæ*.

The formulæ we have obtained show in a remarkable way when applied to the case of an ordinary transformer the importance of very fine lamination in the iron. Let us for example take the case of a transformer where the current makes 100 alternations per second. In this case $p = 2\pi \times 10^2$, for soft iron σ is about 10^4, and we shall suppose that $\mu = 500$, then $m = \sqrt{2\pi\mu p/\sigma} = 10\sqrt{2}$. The depth to which the magnetic force penetrates is comparable with $1/m$, in this case with $(1/10\sqrt{2})$ cm. or ·7mm. Thus in order to bring the whole of the iron into play the plate must not be more than 1·5mm. thick. The following table gives the loss of energy per second from eddy currents for plates of different thicknesses; the magnetic force outside the plate is supposed to be the same in all these cases, and the loss of energy in an infinitely thick plate is taken as unity.

Thickness of plate in millimetres.	Loss of energy per second due to eddy current.
Infinite	1
4	1
2	1·1
1	0·47
0·5	0·057
0·25	0·0075

Thus the loss of energy in a plate $\frac{1}{2}$ mm. thick is only about $\frac{1}{8}$ of the loss in a plate 1mm. thick. Thus, by building up a given thickness of iron in a transformer of plates 5mm. thick, the loss of energy will only be one quarter of what it would be if the plates were 1mm. thick. We see, too, that the lamination is of little use in checking the eddy currents if the plates are more than 1mm. thick. From the expression for w it follows that any increase in the rate of alternation of the current or the magnetic permeability of the iron demands a diminution in the thickness of the plates. I need not enter further into the practical consequences of these results, as I believe they are engaging the attention of Prof. Ewing.

NOTE ON THE USE OF THE ELECTRO-DYNAMOMETER.

BY WM. BREW.

The effect of neighbouring closed circuits upon an electro-dynamometer carrying an alternating current sometimes causes a considerable error in observation, and with some metal mounted instruments a deflection may be obtained by passing an alternating current through the swinging coil alone. The following method of investigating this effect, making, *pro tem.*, one of the stationary coils the disturbing influence, may be of interest:—

Close up the circuit of one of the stationary coils with a non-inductive resistance, r, equal to that of the swinging coil, and join up the other stationary coil in series with the swinging coil, then upon passing an alternating current of known strength, i_1, through these two coils, a secondary current, i_2, will be induced in the closed stationary coil, due to the mutual induction between the two stationary coils alone, if the effect due to any mutual or self-induction of the swinging coil be eliminated by taking the average of two readings with the swinging coil at equal angles on either side of its normal rectangular position. Note this average force reading F_1 upon the torsion head. Now pass the current i_1 through the stationary coil alone, and connect the swinging coil in series with the closed coil taking the place of the resistance r, and note again the average force reading F_2. Writing out the values of F_1 and F_2 we have:—

$$F_1 = i_1 G (g i_1^2 - g i_2^2) \cos\phi \quad . \quad . \quad . \quad (1)$$

$$F_2 = i_2 G (g i_1^2 - g i_2^2) \cos\phi \quad . \quad . \quad . \quad (2)$$

where ϕ is the angle of lag between the phase of the effective field due to the currents i_1 and i_2 in the stationary coils and the current in the swinging coils;

where G, g_1, g_2, are geometrical constants depending upon the coils.

From these two equations we see that

$$\frac{F_1}{F_2} = \frac{i_1}{i_2}, \quad \text{or,} \quad i_2 = i_1 \frac{F_2}{F_1} \quad . \quad . \quad . \quad . \quad (3)$$

The current i_2 in the closed coil thus becomes known irrespective of its difference in phase with i_1; i_2 might also have been due to a separate source of E.M.F. having the same period as i_1.

From the well-known relation—

$$\frac{i_1}{i_2} = \frac{\sqrt{R^2 + p^2 t^2}}{M p},$$

(where the right hand numerator represents the impedance of the closed circuit and the denominator the product of the coefficient of mutual induction M between the coils by 2π times the frequency). It will be seen that, having determined some of the constants of the coils we may adapt the instrument for a variety of purposes, such as the determination of an external impedance of low resistance in circuit with the closed coil, &c.

For general experimental work with the electro dynamometer, a dial of the following kind will be found a convenient adjunct. The graduation of the dial consists of two concentric circles, one of which indicates the square root of any deflection in any arbitrary measure, the only condition being that the number of divisions in the primary circle, from which the square-root circle is obtained, should be greater or less in accordance with the maximum current to be measured by the instrument, so as to keep the constant near unity. The other circle indicates at each point the logarithm of the square root of the deflection. Using the dial in the ordinary way, the logarithm corresponding to any deflection is read off the logarithm scale, and added to the logarithm of the constant. The pointer is then turned to the logarithm represented by this sum, and the number opposite to it is read off the square root scale which will be numerically equal to the current represented by the original deflection.

The dials of many zero ammeters containing iron show them to be practically electro dynamometers with variable constants due to the saturation of the iron in them as the current increases. The following experiment with two well-known types of ammeter, A and B—A containing a quantity of iron, B, on the other hand, possessing very little—may, perhaps, serve to illustrate one of the uses of the dial just described:—

A			B		
Current in amperes.	$\sqrt{\text{Deflection.}}$	Corresponding constant.	Current in amperes.	$\sqrt{\text{Deflection.}}$	Corresponding constant.
15·5	3	5·1	10·3	3	3·43
35·5	7	5·0	17·5	5	3·5
40·6	8	5·0	22·0	6	3·6
45·5	9	5·0	27·0	7	3·8
50·0	10	5·0	32·0	8	4·0
59·8	12	4·9	37·7	9	4·1
62·3	13	4·8	44·3	10	4·4
72·0	15	4·8	84·0	15	5·6
89·0	18	4·9	102·5	17	6·0

From the third column of the above table the slope of the magnetisation curve of the iron may be deduced, the variation of the instrument's self-induction, &c.

A potent factor which tends to make us keep the electro-dynamometer with its degree dial and constant, instead of converting it into a direct reading instrument, is the great saving of time accomplished in calibration by the *approximate* adjustment only of the spring to the range required (which is all that is necessary if a constant be used with the instrument), and the difficulty of obtaining a number of steel springs exactly the same as regards temper, &c. It is, of course, quite a straightforward job to adjust a spring approximately and graduate a dial to suit it, but this course would be very expen-

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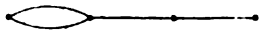
sive with every instrument, and a considerable saving is obtained by having 50 or 100 dials engraved at the same time to the same scale. But it is here the shoe pinches, for with every instrument the spring must be adjusted exactly to the dial. Steel springs seem to have answered best for this purpose according to most makers, probably on account of the weight of the moving parts and the considerable torsion required; but during many a struggle I have had with a steel spring I have heartily wished for the introduction of some other metal as a substitute, one similar to the alloys now being used so generally for smaller electrical measuring instruments. It will be seen that the dial described will adapt itself to the above circumstances, thus cheapening the cost of a direct reading instrument.

THE COMBINATIONS OF RESISTANCES.

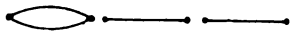
BY MAJOR P. A. MACMAHON, R.A., F.R.S.

Resistances may be placed in circuit either in series or in parallel, or in various combinations of these methods. There are also networks such as the Wheatstone net, which are neither series nor parallel arrangements, and these are excluded from what follows. Every combination considered here consists of other combinations either in series or in parallel. Each must either consist of parallel combinations arranged in series, or of series combinations arranged in parallel. For the study of the subject it is convenient to make a few definitions. Two linear conductors may be placed either in series or in parallel. These arrangements may be defined as being conjugate the one of the other. It will be observed that the second of the arrangements merely differs in description from the first by the substitution of the word "parallel" for the word "series." To generalise the notion we may define two combinations to be conjugate when their descriptions merely differ by the interchange of the words "series" and "parallel."

A single linear conductor should, for the sake of unity, be regarded as being either in series or in parallel, and, further, as being a combination which is self conjugate. A combination consisting of parallel combinations in series will be called a series combination, and one consisting of series combinations in parallel a parallel combination. Thus, in the usual diagrammatic representation,



is a series combination, consisting of the three parallel forms

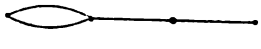


in series; and

is a parallel combination, consisting of the three series forms

in parallel.

The combinations into which series and parallel combinations are decomposable will be termed component parallel combinations and component series combinations respectively. The conjugate of any series combination is formed by placing the conjugates of the component parallel combinations in parallel. Similarly, the conjugate of any parallel combination is formed by placing the conjugates of the component series combinations in series. That this is so is evident, because by taking the conjugates of the component combinations, we merely interchange the words "series" and "parallel" in their descriptions.

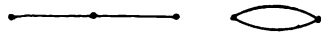
The form  might be described by saying that two single forms are placed in parallel, and the combination then placed in series with two single forms. So also the form consists of two single forms placed in series, the combination being placed in parallel with two single forms. These two forms are thus conjugate, and may be said to constitute a conjugate pair.

It may be gathered that all combinations naturally arrange themselves in conjugate pairs.

For one, two, three, four resistances, we have

I.

II.



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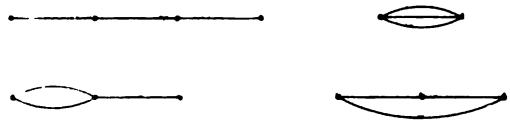

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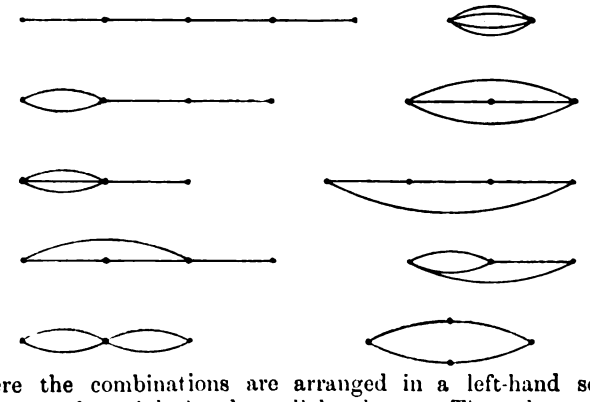


where the combinations are arranged in a left-hand series column and a right-hand parallel column. The columns are conjugate, the one of the other. Conjugate pairs are found in successive horizontal rows.

In a similar manner the combinations of any number of resistances may be arranged in conjugate pairs.

It will be remarked that no attention is paid to the actual values of the resistances, but only to the *forms* in which they can be combined. The enumeration of the forms of combinations of a given number of resistances is of considerable interest. It can be shown that if $2A_n$ represents the number of combinations in the case of n resistances (n greater than one)

$$(1-x)^{-1}(1-x^2)^{-A_2}(1-x^3)^{-A_3}(1-x^4)^{-A_4}\ldots\ldots$$
$$= 1 + x + 2(A_2x^2 + A_3x^3 + A_4x^4 + \ldots\ldots\ldots$$

If the left-hand side of this identity be expanded by the binomial theorem, and comparison made with the right-hand side, the numbers in question are easily calculated. The results are

$2A_2$	$2A_3$	$2A_4$	$2A_5$	$2A_6$	$2A_7$	$2A_8$	$2A_9$	$2A_{10}$ .....
2	4	10	24	66	180	522	1532	4984.....

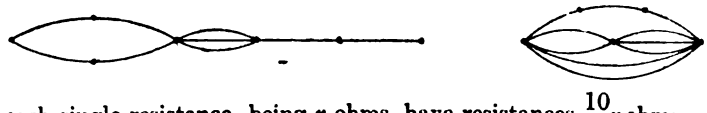
There is in regard to the combinations of equal resistances a very pretty and simple theorem which appears to have hitherto escaped notice.

If any number of resistances, each of r ohms, be combined so as to have a resistance of

$$\frac{p}{q}\ r \text{ ohms},$$

then the conjugate combination of resistances will have a resistance of $\frac{q}{p}\ r$ ohms.

In fact, conjugation merely inverts the fraction which presents itself as the multiplier of r. As an example, the conjugates,



each single resistance being r ohms, have resistances $\frac{10}{3}r$ ohms and $\frac{3}{10}\ r$ ohms respectively.

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The inductive proof of the theorem is very simple. For suppose the law to hold in the case of two combinations whose resistances are

$$\frac{a}{b}\,r \text{ ohms and } \frac{c}{d}\,r \text{ ohms.}$$

The resistance obtained by placing these two combinations in series is

$$\left(\frac{a}{b}+\frac{c}{d}\right) r \text{ ohms.}$$

The conjugate of this new combination is obtained by placing the conjugates of the component combinations in parallel, and since the law is assumed to hold for the component combinations, the resistance obtained will be

$$\frac{\frac{b}{a}\cdot\frac{d}{c}}{\frac{b}{a}+\frac{d}{c}}\,r \text{ ohms,}$$

which is

$$\frac{1}{\frac{a}{b}+\frac{c}{d}}\,r \text{ ohms.}$$

This proves that the law holds for the new combination.

Similarly assuming the law to hold in the case of two combinations of resistance, $\frac{a}{b}\,r$ ohms and $\frac{c}{d}\,r$ ohms, we obtain, by placing them in parallel, a new resistance

$$\frac{\frac{a}{b}\cdot\frac{c}{d}}{\frac{a}{b}+\frac{c}{d}}\,r \text{ ohms.}$$

And, moreover, the resistance obtained by placing their conjugates in series is

$$\left(\frac{b}{a}+\frac{d}{c}\right) r \text{ ohms,}$$

and

$$\frac{b}{a}+\frac{d}{c}=\frac{1}{\frac{\frac{a}{b}\cdot\frac{c}{d}}{\frac{a}{b}+\frac{c}{d}}}.$$

Hence, since every combination is decomposable into two combinations, either in series or in parallel, and the law is obviously true for the simpler cases, it must hold universally.

According to the definition here made of the word "conjugate," it will be remarked that capacities of condensers combine according to the law of the conjugate combinations of resistances.

DIELECTRIC HYSTERESIS.*

BY CHAS. STEINMETZ.

In a Paper read before the American Institute of Electrical Engineers on January 19, 1892 (see *The Electrician*, February 12, *et seq.*), I have proved by experimental data, that the loss of energy in iron and other magnetisable bodies, under alternating magnetic strain, is expressed by the formula,

$$H=\mu B^{1.6},$$

that is, proportional to the $\frac{1}{6}$th power of the intensity of the magnetic field.

The analogy existing between the behaviour of dielectric bodies in an electrostatic field with that of a magnetic body in a magnetic field suggested that in dielectric media in an electrostatic field, for instance in the insulating medium of a condenser which is alternately charged and discharged, a consumption of energy takes place, which depends upon the intensity of the electrostatic field according to a law similar to that of magnetic hysteresis.

That in the dielectric medium of a condenser, which is connected with an alternating E.M.F., a consumption of energy takes place, is known from the fact that the condenser gets hot, while it does not get hot when connected to a source of equal, but constant potential.

To determine this loss of energy and its dependence upon the E.M.F., I made towards the end of January, 1892, a number of tests with a condenser of three microfarads capacity, with paraffin paper as insulating medium, by connecting this condenser in an alternating-current circuit of 170 complete periods per second, and measuring the energy consumed by the condenser in a similar manner, and with the same apparatus that was employed in the tests on magnetic hysteresis.

After subtracting the energy consumed by the leakage current—which was found by testing with a continuous current of equal E.M.F.,—and the energy consumed by the instruments, it was found that :—

The energy consumed by the dielectric medium under alternating electrostatic strain is directly proportional to the square of the intensity of the electrostatic strain; that is, proportional to the square of the E.M.F. acting upon the condenser; or, expressed in symbols,

$$H=k\,E^2.$$

Hence, while the magnetic hysteresis follows the law of the $\frac{1}{6}$th power, the dielectric hysteresis follows a simple law of squares—that is, it acts just the same as a mere dead resistance connected into the circuit.

The tests covered the range from 80 volts up to 320 volts, and agreed very nicely with the law of the square. Beyond 320 volts the dielectric medium apparently began to give way, and the energy-consumption increased faster than proportional to the square of the E.M.F. That was still more marked in a second set of observations, made right after the condenser was overstrained. Here the deviation from the law of squares began even at a lower E.M.F., and the energy-consumption increased so rapidly with increasing E.M.F. that the tests had to be interrupted. In a third set of tests, on the next day, the dielectric had somewhat recovered; the energy-consumption remained proportional to the square of the E.M.F. up to about 250 volts, then increased more rapidly, and then suddenly increased very much, while the E.M.F. went down, and a hissing noise was heard in the condenser; it had given way.

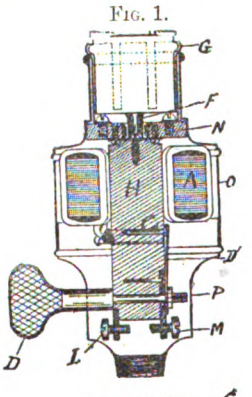
From the above we derive the conclusion, that up to an E.M.F. at which the dielectric begins to break down the energy-consumption in the dielectric of a condenser is proportional to the square of the E.M.F. acting thereupon.

* From the *Electrical Engineer* of New York.

THE RIES REGULATING SOCKET.*

This device for enabling a glow lamp to be "turned down" like a gas burner, consists of a small choking coil mounted in a lamp holder. The accompanying illustrations explain the construction of the socket. Fig. 1 is a sectional elevation, Fig. 2 a side elevation with part of enclosing shell broken away, and Fig. 3 a diagram view showing the coil and circuit connections. As will be seen, the socket comprises a finely laminated iron ring A, wrapped at one operation with a cable, B, composed of a number of well-insulated

Fig. 1.



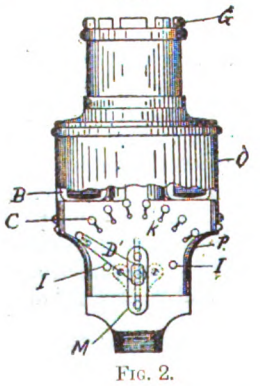


Fig. 2.

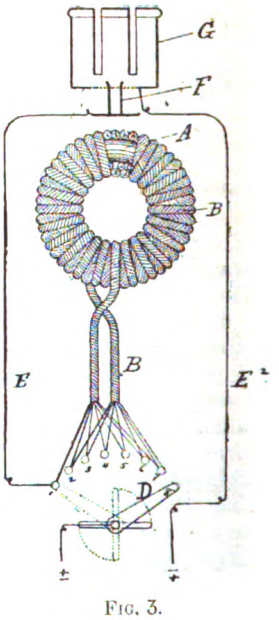


Fig. 3.

* From the *Electrical Engineer* of New York.

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No. of contact on switch.	Impressed E.M.F. (V_1)	Volts between lamp terminals. (V_2)	Volts on coils in circuit. (V_3)	Amperes	Resistance of lamp.	Resistance of coils.	Apparent watts in lamp.	Apparent watts in coils.	Apparent total watts.	True watts in lamp.	Total true watts.	Ohmic loss in coils.	Inductive loss, hysteresis, &c.	Total watts lost in coil.	Efficiency in %, or ratio of total watts used to watts absorbed by lamp.
0	51·25	51·25	0·00	1·146	44·7	0·00	58·8	0·0	58·8	58·8	58·8	0·00	0·00	0·00	100
1	51·00	46·50	16·50	1·048	44·4	1·41	48·7	17·3	66·0	48·7	50·6	1·48	0·42	1·90	96·2
2	52·50	42·50	23·50	0·940	45·2	1·86	40·0	22·1	62·1	40·0	44·4	1·75	2·65	4·40	90·1
3	52·00	35·50	29·50	0·818	43·4	2·50	29·0	24·1	53·1	29·0	35·6	2·05	4·55	6·60	81·5
4	52·00	30·00	35·00	0·676	44·4	3·19	20·3	23·7	44·0	20·3	26·8	2·15	4·35	6·50	75·7
5	52·50	24·00	41·50	0·552	43·5	4·06	13·2	23·0	36·2	13·2	18·5	2·21	2·96	5·20	71·9
6	53·00	17·50	45·50	0·390	44·8	5·27	6·8	17·7	24·5	6·8	11·6	2·05	2·75	4·30	58·6

copper wires, the ends of which are brought to a row of contact pins, C, arranged in the path of an arm, D, connected to the operating key, in such a manner that all of the wires of the cable are, by means of these pins, connected in series with each other and with the lamp. The coil thus formed is mounted upon an insulating block H, contained within the enclosing shell, to which block are likewise secured the lamp-holding contacts, the operating key and the binding screws L M to which the leading-in wires are attached.

The amount of counter E.M.F. generated by this socket varies according to the position of the operating key and its arm. The coil is so arranged that when the arm D is removed from its open-circuit position at the extreme right and rests upon contact No. 7, Fig. 3, all of the winding B is in circuit with the lamp. In this position the counter E.M.F. generated by the coil is greatest, so that only a small portion of the applied voltage, sufficient to just render the lamp filament visible in the dark, is permitted to pass to the lamp. As the arm D is moved toward the left over the series of contact pins C, it cuts out successive sections of the winding B, thereby reducing the length of wire subjected to the inductive action of the core A, and correspondingly increasing the amount of light given by the lamp, until when the arm finally rests upon contact No. 1, all of the coil sections are cut out, and the lamp burns at its greatest brilliancy.

The following test of the Ries socket for varying the candle-power of lamps supplied with alternating currents, was made by Mr. Henry Stott with a view of determining the efficiency of the device. The socket tested was marked "50 volts, 25 c.p.," but as no 25 c.p. lamps were at hand a 16 c.p. was used, and from the fact that, when the switch was on the last step, putting all the coils in circuit, the filament only gave a dull red glow of about a quarter of a candle, it seemed quite well suited to this lamp.

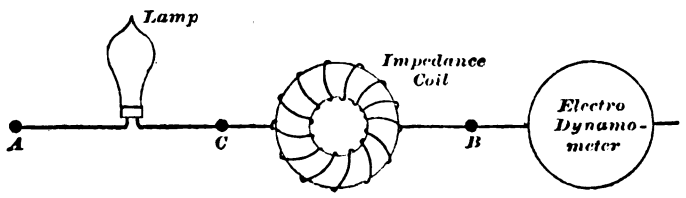

FIG. 4.

The method of carrying out the test was one described by Messrs. Ayrton and Sumpner, with a slight modification to suit the case, the rationale of which is briefly as follows, referring to the accompanying diagram (Fig. 4) :—

Let V_1 = Difference of potential between points A and B.
" V_2 = " " " " " A and C.
" V_3 = " " " " " B and C.
" r = Resistance of lamp.

The watts expended in coil $= \frac{V_1^2 - V_2^2 - V_3^2}{2r}$.

As the resistance of the lamp was a variable, an ammeter on the dynamometer principle was inserted, and the value $\frac{V_2}{a}$ substituted for r, a being the current measured in amperes.

The formula then becomes

$$W = \frac{V_1^2 - V_2^2 - V_3^2}{2\frac{V_2}{a}} = a\frac{(V_1^2 - V_2^2 - V_3^2)}{2V_2}.$$

All readings were taken simultaneously, the volts being read on the Weston type of voltmeter by simply releasing the spring, which stops the motion of the needle, at the same moment that the ammeter was read, and the reading noted before again releasing the needle. The ohmic resistance of the coils was determined immediately after the test by the ordinary bridge method. The paradox of the sum of two E.M.F.'s being greater than the E.M.F. supplied is well illustrated in the table given, as in one case it exceeds the E.M.F. on the mains by 13·5 volts. The accompanying table gives the results of the test, and shows the efficiency of the socket at various degrees of incandescence of the lamp.

ON THE THEORY OF THE AUTOMATIC CONTACT-BREAKER.*

BY V. DVORÁK.

The author points out that in the original theory of the spring cut-out (the inaccuracy of which was indicated by Koppe) the effect of the electro-magnet on the keeper, during the return to the original position, is entirely overlooked, and its attraction is only considered when the keeper is in the position of rest. Since the effects of the actual attractions referred to must be equal and opposite, they can contribute nothing towards the maintenance of the vibrations, supposing that we neglect other important circumstances. The other ways in which the vibrations of the hammer can be affected will now be investigated. They include the retardation of contact, self-induction, the influence of the iron, the dimensions of the core and hysteresis. A complete theory of Wagner's hammer can then be constructed. The curve formed by the increasing current on making contact can be represented by two incomplete sine curves differing by T/4 in phase. The first represents the force which is proportional to the distance from the position of equilibrium, and is in operation only during the movement of the keeper from this position up to the magnet and back again, that is during half a vibration. It can have no influence on the maintenance of the vibration which is kept up by the second curve differing in phase by T/4. It is this, therefore, that has to be attended to in the winding in order to make the amplitude of the vibration as great as possible. With a specially constructed Wagner-Elsa's hammer, which depended on the torsional vibration of an elastic wire, an approximate determination of the energy necessary to maintain the vibrations was arrived at. The result proved that such a hammer must be regarded as an extremely inefficient motor, as approximately only about 1 per cent. of the energy was applied in maintaining the vibrations.

The most important conclusions are as follows:—Owing to the small amount of energy requisite for maintaining the vibrations, the resistance of the cells must be kept quite low. Also the resistance of the magnets must not be too great, as this does not conduce to reliability and powerful action of the bell. As to whether the design could be best improved by the use of a shunt or an extra current circuit (in large bells) or a closed secondary coil, the author does not decide. If the circuit breaker is to be made specially powerful (*e.g.*, for acoustic purposes), the former means can be used with advantage; in particular, the ratio of the coefficient of self-induction to the total resistance must be given a suitable value, and this must be considered in determining the number of ampere turns.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, April 8th.

PHYSICAL SOCIETY.

5 p.m. Ordinary meeting. Papers to be read: (1) "Note on a Law of Colour in its relation to Chemical Constitution." By William Akroyd. (2) "On the Construction of a Colour Map." By Walter Baily, M.A. (3) "A Mnemonic Table in connection with Electrical Units." By William Gleed, M.A.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Electric Meters, Motors and Money Matters." By Prof. W. E. Ayrton, F.R.S.

TUESDAY, April 12th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary meeting. Paper to be further discussed: "The Sewage Farms of Berlin." By H. Alfred Roechling, Asoc. M.Inst.C.E.

* Wiedem. Ann., Vol. 44.

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GOOD FRIDAY WEEK.

"THE ELECTRICIAN" will be published on THURSDAY in Good Friday week, instead of Friday.

Contributors' and Advertisers' copy must reach the Office by Wednesday at latest.

THE COMPOUND WINDING CASE.

Although of comparatively trifling importance so far as the royalties were concerned, the compound winding patent, which has at last been finally upset in the House of Lords, removes one more of those burdens which the patent system allows to harass, if not to impede, the industries of this country. These burdens are fortunately so few that they do not even in the aggregate constitute a serious objection to the patent system, but for various reasons they are peculiarly vexatious. In this particular instance, the Brush Corporation acquired, among numerous other patents, one which described the addition of a "teazer" or shunt winding, which was to overcome the difficulty in series-wound machines, since in these "as ordinarily constructed, no magnetic field," says the specification, "is maintained when the external circuit is open, except that due to residual magnetism." The dynamo described in this patent was for electro-plating, and it was suggested that this construction would enable it to do a large quantity of work at one time and a small quantity at another time. The inventor had not the slightest idea about running glow lamps, which were hardly thought of, or about distribution at constant potential, which LANE FOX had not yet propounded, and the Directors of the Brush Corporation had no notion of the fact that among their patents there was one which might turn out to be of such unexpected value. After careful disclaimers in 1882 and 1886, the Brush Corporation, who were merely making the most of their property, began to demand royalties. The demand was felt to be vexatious, because everybody knew that the first real compound-wound dynamo

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was built by Mr. Crompton, to the designs, we believe, or under the superintendence of Mr. Swinburne.

We have described the earlier part of the fight on a former occasion, and need only remind our readers that it was found by a small association of dynamo makers, who began to prepare a case, that it would be cheaper to pay the royalty of 10s. per unit, adding the amount, of course, to their price lists. The Chairman of the Brush Corporation had no right whatever to say, in 1889, that the controlling patent for compound winding had been admitted by the English makers. Messrs. King, Brown and Co. took a more high-spirited view; and, while declining to pay what they considered to be an unjust tax, have squandered more money on the legal profession than would have paid their royalties a dozen times over. We cannot but grudge that so much money should have been lost to the electrical trade. This enterprising Scotch firm are to be congratulated on freeing the whole industry from the payment of a royalty which would have been viewed in a very different light if it had really been asked for a genuine invention, either made by one of the staff of the Corporation or openly bought, like many other patents, for their apparent purpose. It is this manipulation of the meaning and twisting of the text, and putting into a patent that which the inventor never dreamed of, that encourages "fishing" patents. There are one or two patents still hanging over the electrical trade—the Hopkinson three-wire system, and the Edison feeder system. The lamp-holder and double-carbon arc lamp patents are no longer to be feared; but if multiphase motors come into general use there will probably be some attempt to set up a general claim.

Previous to the Act of 1883 it was optional with the patentee whether he would grant licences authorising other persons to use his invention; but now, if any person petitioning the Board of Trade proves that the patent is not being worked in the United Kingdom, or that the reasonable requirements of the public cannot be supplied, or that any person is prevented from working or using to the best advantage an invention of which he is possessed, the Board of Trade may compel the patentee to grant licences, and may order the amount of royalties, security for payment, &c., as, having regard to the nature of the invention and the circumstances of the case, they may deem just. This may some day be used to prevent a selfish or oppressive use of the monopoly granted by the patent system, but such compulsory licences have never, so far as we are aware, been applied for; perhaps because no invention of sufficient importance has been made since 1883, or, if made, has not been the occasion of exorbitant demand. Whatever may be said against the compound-winding patent of Brush, it must be admitted that the Brush Corporation did not set their claims too high. They did not wait for years and spring an unknown patent on an unsuspecting trade; the royalty was substantial, but could without serious difficulty be recovered from the purchasers of dynamos. It was not sufficient to place the manufactures of the Corporation at any material advantage compared with those of competing manufacturers.

If we are not mistaken, we shall in the future see less of these general and wide-spreading patents applied for by men who, like Brush, Lane Fox, and Edison, dimly saw that they had hit on something. They felt that at that time the air was full of new discoveries, and that every idea should be seized on and secured. Ideas are not more scarce now, on the contrary, they are overwhelming; but we know more clearly what we are working at. A distinct invention for a new contrivance intended for and actually used for a particular object or purpose, or a combination of new or old parts for a definite result, appeals at once to common sense and justice. It is when the invention is used for another purpose, or when the result is arrived at by slightly modified parts, that difficulties begin. Definiteness of aim and clearness of specification are more common to-day than they were twelve years ago; and we hope that twelve years hence these expensive lawsuits will be rare, or, if disputes must arise, that they may be settled in some less costly manner.

OBITUARY.

CHARLES J. VAN DEPOELE.

We regret to have to record the death of Mr. Charles J. Van Depoele, at Lynn (Mass.), on March 18th.

Mr. Van Depoele, who was in his forty-sixth year, was a Belgian by birth. In 1864 his family removed to Lille, France, and in a short time the young man attracted the attention of Dr. Patoir through his electrical experiments and exhibitions of electrical apparatus. In 1869 Mr. Van Depoele went to Detroit, Michigan, where he continued his experiments. Many different styles of lamps were made and experimented with, and not less than fifteen different styles of dynamos were made and tested, with all sorts of combinations and winding. The studies and experiments were continued vigorously, and every now and then Mr. Van Depoele gave an exhibition of the electric light to the public. In 1879 he lighted up Adam Forepaugh's circus; a few days later the Detroit Recreation Park, the Detroit Grand Opera House, &c. These exhibitions attracted the attention of capitalists, who cheerfully offered their assistance, and the experimenting shops were transferred to the Detroit Novelty Works in Hamtramck, where several new machines were built and experiments continued until 1880, when a company was formed to enter upon the manufacture of electric light machinery. Finding, however, that Detroit was not the real field, the Company was transferred to Chicago, where a new Company was formed, under the name of Van Depoele Electric Manufacturing Company. This Company experimented in electric railway work, and in 1887 had 13 electric railways in successful operation, the first one being at South Bend (Ind.), which was equipped in 1885. In March, 1888, the Van Depoele Electric Manufacturing Company sold their electric railway business to the Thomson-Houston Company, Mr. Van Depoele being engaged as inventor and electrician to the Company, which position he occupied up to the time of his death.

REVIEWS.

The Electric Railway in Theory and Practice. By Oscar T. Crosby and Louis Bell, Ph.D. New York: The W. J. Johnstone Company. London: "The Electrician" Printing and Publishing Company.

The task undertaken by the authors of this book is comprehensive, including, as it does, the historical, commercial, theoretical, and practical aspects of the electric railway; but, as stated in the preface, no attempt is made to give a detailed study. The subject is divided into twelve convenient chapters in a clear and definite manner, so that there is little difficulty in finding the information contained. Special points of practical import are further elucidated in five appendices.

The first chapter refers to the theory of electrical machines, and calls for no special comment other than that the views are clearly expressed in rough general terms, which will appeal to railroad engineers. Exception may be taken to some of the Americanisms; but the use of "electrics" on page 16 seems very happy. On page 22 the length of the keeper—yoke, as we should say—is given as 36in.; it would appear from the context to be 34in. Expressing the armature magnetic density in C.-G.-S. lines per square inch is open to question, though Prof. Silvanus Thompson has used the same mixed units in his class lectures.

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In Chapter II. prime motors are discussed, and the relative advantages of small high-speed simple engines and large compound Corliss engines are considered. The importance of taking frequent diagrams, so as to set the valves at the most efficient point of cut-off, and the necessity for extra heavy fly-wheels with considerable inertia, in order to overcome the rapid variations of power required on small lines, are strongly insisted on. The particular field for turbine or water wheels is also pointed out.

Perhaps the most interesting chapter is that referring to the motor and car equipment. The problem before the motor designer is clearly stated, and the various approximations found most expedient in practice are detailed at length. The two methods of securing a fairly uniform speed by changes in the field excitation or by interpolated resistance are illustrated by numerical examples, and it is shown that experience tends towards a combination of the two. This practice is quite in accord with English and Continental methods, and points to a state of finality in arrangement, if not in detail. Judging from the long list of general instructions given to car drivers, it would appear that a regulation by the field changes only, as formerly practised by the Sprague Company, was productive of no little trouble. For instance, on page 122 occurs the following passage:—"When necessary to go beyond the fourth notch, pass slowly to the seventh, never stopping on the fifth or sixth; and always use the seventh notch on grades." There is, of course, nothing exceptionally difficult in the above instruction; but, judging from English experience, such a complicated arrangement would lead to many "burnt-out" field windings. Perhaps, however, the American driver is more sober than the average tram hand here. It is no wonder, however, that the Edison General Electric Company have lowered the combined field-coils resistance from about 20 to 8·6 ohms, and have put 6 ohms in series with the motor for starting. We note that the Thomson-Houston Company wind the field in two coils, which are coupled in series with each other, and also with an external resistance. After the latter is cut out of circuit one-half of the field wire is cut out as well.

The vexed question of single *versus* double motors is well handled. It is pointed out that in the early days when motors were not so reliable as now, two motors in parallel were a great safeguard; but that now accidents from this cause are so reduced in number that the proper reserve for each car is the car immediately following, which can always push it to the journey's end or the depôt. The efficiency of one large motor and one set of gearing is, say the authors, about 10 per cent. greater than that obtainable with two small motors giving the same tractive effect. Double motors seem to have for their especial field lines serving between residential country districts and cities; then the motors are coupled in parallel outside the city boundary, and run in series within the area where a high speed is not permissible. On pages 81 and 82 the methods of coupling motors in parallel are discussed, and the errors resulting are shown. Varying-ratio gearing is naturally mentioned, but no practical solution of the speed-varying problem is given, though hopes of success in this direction are hinted at. Such a gearing would put railway work on a much better footing. The general methods of gearing motors to axles are detailed at some length, but it is pointed out that straight-cut steel gear seems to give the best all-round results. Raw hide is unreliable, and morticed wheels are difficult to make with the small pitches required. Single and double reduction motors are also compared. Taken all round, it appears that a net gain of at least 5 per cent. efficiency is obtained by the single reduction, and decidedly the wear and tear of gearing is less. But the motor is larger, and, consequently more costly, and has, *per se*, a lower all-round efficiency, particularly if the service demand frequent stops. It is, perhaps, too soon to predict whether the gearless motor will supplant the single reduction. But on high-speed lines with long runs it is likely to do so if the armatures will stand the strain. The Short gearless motor has the armature carried in a separate sleeve with spring attachments; the Westinghouse armature (drum type) is boldly keyed on the rolling axle. The authors point out that the character of the road and service must largely affect the success of these motors, and only time can settle the superiority of one or the other—most likely they each have their particular field of operation in which they are *facile princeps*—the ultimate test is small coal consumption and freedom from breakdowns. The typical American motors are illustrated, and also the general types of motor-trucks. The bogie-trucks for long cars are interesting. On pages 102-104, rough data for estimating the power absorbed by cars under different circumstances are given, and on page 105 the various means of getting sufficient adhesion for stiff grades are detailed.

The trolley receives the attention it deserves, and the principle is clearly evolved. Diagrams of standard car wirings are published, we believe, for the first time. It may seem curious to the untravelled English engineer that cars should be heated as well as lighted by electricity; but although the cost is as high as 72 cents per day, against 10 cents with stoves, yet the greater convenience makes the additional cost permissible. A section of Chapter III. is given to lightning-arresters, and is well worth careful reading (see also Appendix E.). The "line" is discussed in Chapter IV., both mathematically and practically. The most interesting section in it, perhaps, is that relating to the "return" or earth circuit, and the interference with telephones. In Appendix A. are stated two opinions given respectively by the Superior Court of Cincinnati and the Supreme Court in the State of Ohio. It appears at present that the double trolley system will not be insisted on, and that the telephone companies will have to use an insulated metal return, which will vastly improve the communication.

Next the "track" is referred to in Chapter V., and English engineers will be surprised at the variety and curious shapes of the American rails. Generally these appear to be lighter than those used here. On p. 149 the desiderata for a really efficient tram track are mentioned in forcible language by Mr. F. H. Monks. Undoubtedly the sooner tramway companies realise that a well-laid road means less wear and tear of plant, as well as smaller coal consumption, the better. The car house, snow ploughs and sweepers are also illustrated and described.

Chapter VI. is devoted to the station, and the various considerations affecting the choice of position are well set out. The large variation of power (as much as from zero to 150 H.P. and back again to zero in a single minute, being shown in one load diagram on page 164) and the necessity of the strongest and best material in engine and dynamo are insisted upon—these being the more urgent with small lines and heavy grades. On page 171 we find a table of power required at the wheels, with a 16ft. normal car, weighing about five tons empty, for grades varying between 0 per cent. and 5 per cent. The *average* power and the *maximum* power are then discussed in relation to the size of engine and dynamo. Lines of various capacities are enumerated, and the proper size of electric and steam "unit" approximated, examples from practice being given. This chapter is worth very careful perusal, containing, as it does, hints gathered from a large practical experience.

The efficiency of electric traction is treated in a separate chapter, which is by no means the least instructive part of the book. The authors show that the main losses occur in the engine plant, the motor gearing and regulating devices; the efficiency of the dynamo, line, and motor being fairly high, and leaving, in the nature of things, little room for improvement. It is impossible in a review to do more than refer generally to the points at issue. Experience shows that the average power required per 16ft. car with two 15 H.P. motors, is about 6 to 8 E.H.P., and in few roads does it exceed 10 E.H.P. under normal conditions. The authors state that the dynamos should have a rated capacity of half the aggregate rated capacity of the motors. But the engine-rated capacity (I.H.P.) should not be more than about 75 per cent. of that of the dynamos. By these proportions the engines will be worked on the average near their points of maximum efficiency. The dynamo efficiency, of course, varies little between half and full load. Such a plant will have a small coal consumption and yet will meet the varying demands of power promptly and without undue strain to either engines or dynamos. Line and conduit difficulties, motor efficiency and gearing, are also discussed under this

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head. The authors find the average commercial efficiency from car wheel to engine to be about 40 per cent. with present practice, and look to a possible average efficiency of from 50 to 60 per cent. in the future on large and well planned lines. The coal consumption may be gathered from data given to vary between 5lb. and 7lb. per car mile.

The question of storage battery traction is introduced and characterised by the following drastic description :—"Manners none; customs beastly." This sweeping criticism is, perhaps, hardly justified in view of recent improvements made in traction accumulators both in Europe and America. But after thus showing their own predilections the authors settle down to a pretty fair discussion of the position of the self-contained car, at any rate so far as America is concerned. The battle really turns on whether the overhead or the conduit system be permissible; if neither be so, then the accumulator or the horse car has the field, and it is really a simple question of cost between the two systems. The authors very rightly point out that it is by no means certain that any type of accumulator in the market to-day will necessarily share in the ultimate success of this form of traction.

Chapter IX. deals with conduit, third rail, and constant-current systems, and even telpherage is not forgotten. The authors then give a chapter to "high speed service," and discuss at length the pros and cons of obtaining a rate of 150 miles per hour by means of electric motors. The subject is well handled and carefully treated; but, the authors remark, it is not easy to-day to make even an "educated guess" as to the limiting speed of either steam or electricity. Probably the commercial aspect is the more important for the present. It certainly seems probable that if the demand were made the engineers would meet it. High-speed resistances are known to be much less than supposed by our leading authorities of 20 years ago or more. This chapter very fitly concludes with the favourable though guarded report of Prof. Henry A. Rowland and Dr. Louis Duncan on Mr. Crosby's figures.

Commercial considerations are discussed in Chapter XI. This should form very instructive reading for tramway managers and engineers. Although the figures are based on American experience, there will be little difficulty in converting most of them to the prevailing rates of any given district. On page 323 is a so-called "curve of coefficient of rides per capita in cities of the United States." The ordinates are "rides per capita per annum," and the abscissæ are the population of cities measured by thousands. The authors state that experience shows that at the present rates of fare—almost everywhere 5 cents—each car, running an average of 110 miles per day, must carry from 330 to 440 passengers per day "to live." It thus follows that the possible number of paying cars can be readily told by inspection of the curve. Following next comes a table giving the "Street Railway Statistics for 50 Cities." It will be noticed that the number of cars reported is always in excess of the number of "cars possible to be supported," as determined by the previously mentioned table; but a foot note draws attention to the fact that many of the cars are old, obsolete, or in reserve. From the above it would appear that an American line requires to earn from 30s. to 40s. per day per car in order to pay its way. These limiting figures will form no guide to English practice, since the conditions of running are altogether different.

The curious increase of traffic on lines converted from horse to electric systems is strongly supported by figures. The authors state that the increase in gross receipts varies from 25 per cent. to 300 per cent., and is rarely less than 30 per cent., even when the previous horse service has been good. These facts speak for themselves, and stand in strong judgment on the policy pursued in this country.

The historical notes are of no particular interest, being chiefly a summary of what we already know. Appendix B. contains clear and minute instructions for wiremen. Appendix C. gives a convenient form of log-book for use by an engineer in charge of a station. Appendix D., compiled by H. L. Bettis, gives a "classification" of expenditures for electric railways. It seems to be based on the Thomson-Houston method of conducting business. Appendix E. is written by Prof. Elihu Thomson, and refers to lightning protection. The subject is clearly treated, and sound practical advice for the safe guarding of station, dynamo and motors is offered.

Broadly reviewed, "The Electric Railway in Theory and Practice" is a well-written compendious text-book. Perhaps the fault most apparent is inherent in the subject, *i.e.*, the mass of information extant is so voluminous that it is impossible to cram into the 400 pages the whole of even the more important matter. So that some readers will miss what they most want, or find it insufficiently dealt with. In a future edition the historical section might with advantage be omitted, and the utility of the book would be largely increased by a sub-division of the contents into two volumes, one referring to theory and practice, and the other dealing with the commercial features only. The index is scanty, but the arrangement of the chapter contents to a large extent redeems this weakness. The style is eminently readable, and remarkable for the entire absence of "spread-eagleism." A good feature, which English writers might copy with advantage, is the sparse occurrence of the names of inventors both real and so-called. A. T. S.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(Continued from page 543.)

§ 74. **Comparison of Mean Radii of Coils.**—In preceding paragraphs a very full explanation has been given of the important fact that the only fundamental "constant" of a properly designed current-weigher is the ratio of the mean radius of one of the fixed coils to that of the suspended coil. Let us now consider how Lord Rayleigh* determined this ratio with great accuracy. The ratio of the mean radii can be deduced from the ratio of the "galvanometer constants" by the introduction of some small corrections, as was explained in § 29. In § 28, a demonstration was given of the following result:—If a_1 is the mean radius of a coil, supposed of rectangular section, $2k_1$ the radial depth, $2k_1$ the axial depth of the windings, n_1 the number of turns of wire, and G_1 the galvanometer constant, then

$$G_1 = \frac{2\pi n_1}{a_1}\left\{1 + \tfrac{1}{3}\frac{k_1^2}{a_1^2} - \tfrac{1}{2}\frac{k_1^2}{a_1^2}\right\},$$

neglecting powers and products of k_1/a_1, k_1'/a_1, higher than the second. Thus, if the suffix $_2$ distinguishes quantities belonging to the second coil, we have

$$\frac{a_2}{a_1} = \frac{n_2 G_1}{n_1 G_2} \cdot \frac{1 + \tfrac{1}{3}\frac{k_2^2}{a_2^2} - \tfrac{1}{2}\frac{k_2'^2}{a_2^2}}{1 + \tfrac{1}{3}\frac{k_1^2}{a_1^2} - \tfrac{1}{2}\frac{k_1'^2}{a_1^2}}.$$

In Lord Rayleigh's work the quantities k/a, k'/a were quite small, so that an approximate knowledge of their values was sufficient. Thus he found for the suspended coil

$$1 + \tfrac{1}{3}k_2^2/a_2^2 - \tfrac{1}{2}k_2'^2/a_2^2 = 1 + \cdot000741 - \cdot002269 = 1 - \cdot001528,$$

and for the fixed coil

$$1 + \tfrac{1}{3}k_1^2/a_1^2 - \tfrac{1}{2}k_1'^2/a_1^2 = 1 + \cdot000225 - \cdot000457 = 1 - \cdot000232.$$

To compare the galvanometer constants, the two coils are placed with their planes in the magnetic meridian, and their centres coincident. If this setting is carefully made it will be practically perfect, since any error introduced into the ratio by bad adjustment will depend upon the *square* of the displacement from the proper position. In Lord Rayleigh's experiment the uncertainty in the ratio introduced on this score did not amount to more than 1 in 10,000. At the common centre of the coils is hung a very small magnet with a mirror attached to it, so that its motions can be observed in the usual way by the aid of a lamp and scale. The mirror is enclosed in a glass cell, so as to be uninfluenced by air currents. If currents are

* "The Electro-Chemical Equivalent of Silver," *Phil. Trans.*, Royal Soc., 1885.

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sent round the two coils in opposite directions, it will be possible, by properly adjusting the strengths of the currents, to annul the magnetic force at the centre of the coils due to the two currents. In this case the position of the magnet will be unaffected by the passage of the current. It is important that the magnet should be very short, so that the magnetic field at its ends may not differ sensibly from that at the *centre*. In Lord Rayleigh's experiments the length of the magnet was only 0·1 inch, and the error due to neglecting it could not exceed 1 part in 10,000. The coils are arranged in parallel, as in Fig. 53, a suitable resistance being associated with each coil. If i_1, i_2 be the strengths of the currents flowing through the two coils, then, when a balance is obtained we have $G_1 i_1 = G_2 i_2$, since $G_1 i_1$ is the magnetic force at the centre of the suspended magnet due to the current in the coil (1), and $G_2 i_2$ refers in a similar way to coil (2). But by Ohm's law $R_1 i_1 = R_2 i_2$, so that $G_1/G_2 = R_1/R_2$, R_1 and R_2 being the resistances of the two "parallel" branches.

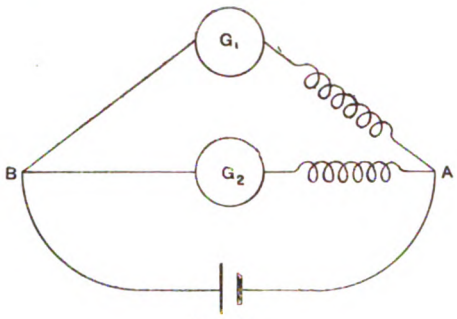

Fig. 53.

To make this method successful there must be some accurate means of determining the ratio of R_1 to R_2. For this purpose Lord Rayleigh arranged the following modification of the arrangements of Fig. 54. The current from a large Daniell cell, A (Fig. 54), after passing the reversing key, B, divides itself at C between the coil D belonging to the electro-dynamometer, and the coil E, the latter being the suspended coil of the current-weigher. The remaining terminals of these coils are led into mercury cups F and H, a resistance box N being associated with the coil E. The terminals of a mirror galvanometer, *g*, are connected to these cups. The cup F is connected to another mercury cup, L, by a standard 10-ohm coil and a resistance box, K, these two being

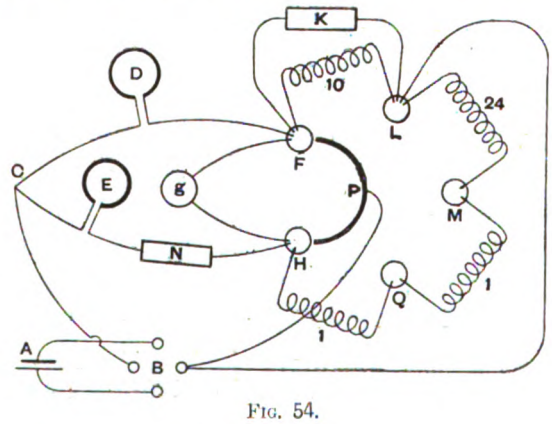

Fig. 54.

arranged in parallel.* The mercury cup, H, is connected to L by means of two standard 1-ohm coils and a 24-ohm coil, whose value is accurately known. The ends of these coils are connected by the mercury cups, Q, M. The current can be led back to the reversing key either from the thick copper horseshoe piece P, which can be inserted into the two cups F, H, or from the mercury cup L. The electro-magnetic balance is first found by inserting P into the cups F, H, and adjusting the resistance N till the position of the spot of light reflected from the mirror at the common centre of the two coils, D, E, is only very slightly affected by the passage of the current. The horseshoe, P, is now withdrawn, so that the current now passes through the standard resistance coils. The resistance in the box K is then adjusted, so that the galvanometer *g* shows no deflection when the current is allowed to pass. It will be noticed that this arrangement constitutes a "Wheatstone's bridge," of which the four "arms" are C F, C H, F L, H L. The operations of finding the electro-magnetic balance and the resistance balance can be so rapidly alternated as to eliminate any error due to changes of temperature in the copper wires.

It is important to note that a knowledge of the *absolute* resistance of the "standard" resistance coils is unnecessary. It is only their *relative* values that are required.

§ 75. **Effect of Self-Induction.**—The electro-magnetic balance cannot be found by making and breaking the battery circuit and attempting to set up a vibration in the magnet suspended at the common centre of the two coils on account of the effects of the self-induction of the coils. On account of this property the currents in the two coils only gradually rise to their final values, and the rates at which they rise are different. Thus, although the magnetic force at the centre of the coils due to the two currents may be accurately zero when the currents have become steady, still, during the time that the currents are being established the magnetic force is by no means zero; and the magnet will be disturbed in the same way as it would if a current of a certain strength were to flow round one of the coils for a very short time. In fact, the effect is the same as if a current of the same strength as the steady current through one of the coils were to circulate round that coil for a time $M\,(1/R_1 - 1/R_2) + L_1/R_1 - L_2/R_2$ seconds,* L_1, R_1 being the coefficient of self-induction and the resistance of one coil, L_2, R_2 similar quantities for the other coil, and M the co-efficient of mutual induction. Lord Rayleigh therefore made no attempt to make the electro-magnetic balance absolutely perfect, but simply found two resistances from the box N differing by about 1/20 ohm, such that the effects observed were reversed in passing from one to the other. The resistance balance, corresponding to each of the two resistances which were taken from the box N, was found by withdrawing the horseshoe P and adjusting the resistance in the box K till the galvanometer *g* showed no deflection. In this way two values of the resistance in K were found such that one was greater and the other less than the resistance, which would have been required for the "resistance balance" if the electro-magnetic balance had been absolutely perfect. From the magnitude of the deflections of the magnet at the centre of the two coils for the two different resistances from N, the required result was obtained by interpolation.

§ 76. **Numerical Example.**—An example will, perhaps, make this clearer. With a certain resistance *a* from the box N the double deflection of the magnet when the battery was reversed amounted to +·8 scale divisions, while with another resistance *b* from N the double deflection was −8·7. Now, with *a* the resistance from K, associated with the [10], and necessary for the resistance balance, had to be such that the resultant resistance of this branch was 9·97772; while with *b* the resultant resistance had to be 9·99182. The resistance which would have been required here if N had been accurately adjusted for the electro-magnetic balance is thus

$$9{\cdot}97772 + {\cdot}8/9{\cdot}5 \times (9{\cdot}99182 - 9{\cdot}97772) = 9{\cdot}97890.$$

* The smallest resistance actually used in the box K was 4,000 ohms. Under these conditions the values of the resistances in the box K need not be known with anything like the accuracy that is necessary for the 10-ohm coil. The method of making a small change in the effective resistance of a coil by arranging a large resistance in parallel with it is very convenient practically, and is very accurate. It was employed by the Electrical Standards Committee of the British Association in their experiments on the absolute unit of resistance, having been suggested to Mr. Fleeming Jenkin by Prof. W. Thomson (now Lord Kelvin). See "B.A. Report," 1863 (Newcastle), or "Reports on Electrical Standards" (Spon, 1873), a valuable book of reference.

* This can be proved by solving the two differential equations

$$R_1 u + L_1 du/dt - M\,dv/dt = E,$$
$$R_2 v - M\,du/dt + L_2\,dv/dt = E,$$

where u, v are the currents in the coils (1) and (2). The "constants" are to be determined by aid of the condition that $u = v = 0$ when $t = 0$. We have also to remember that $G_1/R_1 = G_2/R_2$. The resistance of the battery is supposed negligible.

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The resistance in the other branch (made up of the coils [1], [1], [24]) was 25·95648, so that the ratio of the galvanometer constants was determined to be

$$25{\cdot}95648/9{\cdot}97890 = 260113.$$

On two other occasions Lord Rayleigh found for the ratio the values 2·60087, 2·60098. The sensitiveness of the method was such that the errors of reading could scarcely exceed one part in 10,000. Lord Rayleigh points out that the weakest part of the arrangement is in the standard resistances. He points out that if it were desired to push the power of the method to its limit it would be necessary to design the two coils so that the ratio should be (approximately) expressible by very simple numbers. "If in the present case, for example, we were content to sacrifice one-fifth of the number of turns on the suspended coil, the ratio might be made to approach that of 2:1. The standard resistances might then be composed of three equal resistance coils, which could be more accurately combined and tested than the more complicated arrangements that we are obliged to use." Employing the formula given in § 74, Lord Rayleigh deduced from the ratio of the galvanometer constants the number 2·42113 as the ratio of the mean radius of one of the fixed coils to the mean radius of the suspended coil. The value of A, the mean radius of the fixed coil, was calculated from the dimensions of the coil to be 24·8106cm., so that the value of a, the mean radius of the suspended coil, came out 10·2473cm. Although these two last numbers are recorded to six significant figures they could not have been accurate to anything approaching that number of figures; but, fortunately, in the current-weigher the only quantity which has to be known with the highest accuracy is the *ratio* of the mean radii of the coils, and this is found very satisfactorily by the method of Bosscha, described above.

(*To be continued.*)

DYNAMO-ELECTRIC MACHINERY.*

BY J. HOPKINSON, F.R.S., AND E. WILSON.†

The following is intended as completion of a Paper by Drs. J. and E. Hopkinson (*Phil. Trans*, 1886, p. 331). The motive is to verify by experiment theoretical results concerning the effect of the currents in the armature of dynamo machines on the amount and distribution of the magnetic field which were given in that Paper, but which were left without verification. For the sake of completeness, part of the work is given over again.

The two dynamos experimented upon were constructed by Messrs. Siemens Brothers and Co., and are identical, as far as it is possible to make them. They are mounted upon a common base plate, their axles being coupled together, and are referred to in this Paper respectively as No. 1 and No. 2.

Each dynamo has a single magnetic circuit consisting of two vertical limbs extended at their lower extremities to form the pole-pieces, and having their upper extremities connected by a yoke of rectangular section. Each limb, together with its pole-piece, is formed of a single forging of wrought iron. These forgings, as also that of the yoke, are built up of hammered scrap iron, and afterwards carefully annealed. Gun-metal castings bolted to the base-plate of the machine support the magnets.

The magnetising coils on each limb consist of 16 layers of copper wire 2mm. diameter, making a total of 3,968 convolutions for each machine. The pole-pieces are bored out to receive the armature, leaving a gap above and below subtending an angle of 68deg. at the centre of the shaft. The opposing surfaces of the gap are 1·4cm. deep.

The following table gives the leading dimensions of the machine:—

	cm.
Length of magnet limb	66·04
Width of magnet limb	11·43
Breadth of magnet limb	38·10
Length of yoke	38·10
Width of yoke	12·06
Depth of yoke	11·43
Distance between centres of limbs	23·50
Bore of fields	21·21
Depth of pole-piece	20·32
Thickness of gun-metal base	10·80
Width of gap	12·06

The armature core is built up of soft-iron discs, No. 24 B.W.G., which are held between two end plates screwed on the shaft.

The following table gives the leading dimensions of the armature:—

	cm.
Diameter of core	18·41
Diameter of shaft	4·76
Length of core	38·10

The core is wound longitudinally according to the Hefner von Alteneck principle with 208 bars made of copper strip, each 9mm. deep by 1·8mm. thick. The commutator is formed of 52 hard-drawn copper segments insulated with mica, and the connections to the armature so made that the plane of commutation in the commutator is vertical when no current is passing through the armature.

Each dynamo is intended for a normal output of 80 amperes 140 volts, at 880 revolutions per minute. The resistance of the armature measured between opposite bars of the commutator is 0·042 ohm, and of each magnet coil 13·3 ohms.

In the machine, the armature core has a greater cross-section than the magnet cores, and consequently the magnetising force used therein may be neglected. The yoke has the same section as the magnet cores, and is therefore included therein, as is also the pole-piece. The formula connecting the line integral of the magnetising force and the induction takes the short form

$$4\pi n c = 2l_2\, \mathrm{I}/\mathrm{A}_2 + l_3 f(\nu \mathrm{I}/\mathrm{A}_3),*$$

where

n is the number of turns round magnet.

c is the current round magnet in absolute measure.

l_2 the distance from iron of armature to rim of magnet.

A_2 the corrected area of field.

I the total induction through armature.

l_3 the mean length of lines of magnetic force in magnets.

A_3 the area of section of magnets.

ν the ratio of induction in magnets to induction in armature.

f the function which the magnetising force is of the induction in the case of the machine actually taken from Dr. J. Hopkinson on the "Magnetisation of Iron," *Phil. Trans*, 1885, Figs. 4 and 5, Plate 47.

In estimating A_2 we take the mean of the diameter of the core and of the bore of the magnets 19·8 cm., and the angle subtended by the pole-face 112deg., and we add a fringe all round the area of the pole-face equal in width to the distance of the core from the pole-face. This is a wider fringe than was used in the earlier experiments (*Phil. Trans.*, p. 337), because the form of the magnets differs slightly. The area so estimated is 906 sq. cm.

l_3 is taken to be 108·8 cm.

A_3 is 435·5 sq. cm.

ν was determined by the ballistic galvanometer to be 1·47. It is to be expected that, as the core is actually greater in area than the magnets, ν will be more nearly constant than in the earlier experiments. It was found to be constant within the limits of errors of observation.

Referring to Fig. 1, the curve C is the curve $x = l_3 f(\nu y/\mathrm{A}_3)$, and the straight line B is the curve $x = 2l_2 y/\mathrm{A}_2$, whilst the full line D is the characteristic curve of the machine $x = 2l_2 y/\mathrm{A}_2 + l_3 f(\nu y/\mathrm{A}_3)$, as given by calculation.

* Abstract of Paper read before the Royal Society.

† It must not be supposed from his name not appearing in this short Paper that my brother, Dr. E. Hopkinson, had a minor part in the earlier Paper. He not only did the most laborious part of the experimental work, but contributed his proper share to whatever there may be of merit in the theoretical part of the Paper.—J. H.

* *Phil. Trans.*, p. 335.

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The marks + indicate the results of actual observations on machine No. 1, and the marks 0 the results on machine No. 2, the total induction I being given by the equation :—

$$I = \frac{\text{Potential difference in volts} \times 10^8}{208 \times \text{revolutions per second}}.$$

Experiments made upon the power taken to drive the machine under different conditions show that it takes about 250 watts more power to turn the armature at 660 revolutions when the magnets are normally excited than when they are not excited at all. The volume of the core is 9,465 cub. cm., or in each complete cycle the loss per cub. cm. is

$$\frac{250 \times 10^7}{11 \times 9{,}465} = 24{,}000 \text{ ergs.}$$

The loss by hysteresis is about 13,000 (*Phil. Trans.*, 1885, p. 463) if the reversals are made by variation of intensity of the magnetising force, and the iron is good wrought iron.

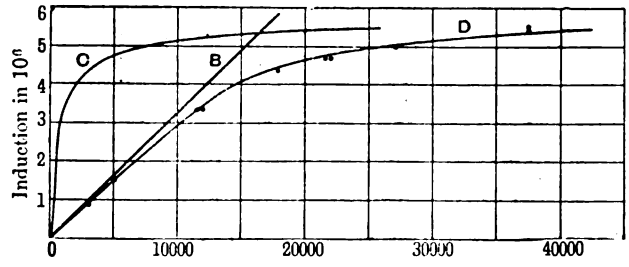

FIG. 1.—Line integral of Magnetising Force.

This result is similar to that in the earlier Paper (p. 352), where it is shown that the actual loss in the core, when magnetised, is greater than can be accounted for by the known value of hysteresis.

Effects of the Current in the Armature.

Quoting from the Royal Society Paper, p. 342, "The currents in the fixed coils around the magnets are not the only magnetising forces applied in a dynamo machine; the currents in the moving coils of the armature have also their effect on the resultant field. There are in general two independent variables in a dynamo machine—the current around the magnets and the current in the armature, and the relation of E.M.F. to currents is fully represented by a surface. In well-

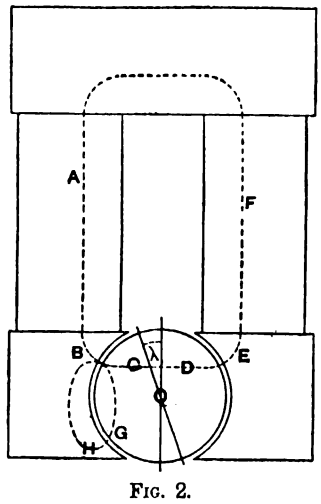

FIG. 2.

constructed machines the effect of the latter is reduced to a minimum, but it can be by no means neglected. When a section of the armature coils is commutated it must inevitably be momentarily short-circuited, and, if at the time of commutation the field in which the section is moving is other than feeble, a considerable current will arise in that section, accompanied by waste of power and destructive sparking.

"Suppose the commutation occurs at an angle λ in advance of the symmetrical position between the fields, and that the total current through the armature be C, reckoned positive in the direction of the resultant E.M.F. of the machine, *i.e.*, positive when the machine is used as a generator of electricity. Taking any closed line through magnets and armature, symmetrically drawn as ABCDEFA (Fig. 2), it is obvious that the line integral magnetic force is diminished by the current in the armature included between angle λ in front and angle λ behind the plane of symmetry. If m be the number of convolutions of the armature, the value of this magnetising force is $4\pi C \frac{m}{2} \frac{2\lambda}{\pi}$ $= 4\lambda m C$ opposed to the magnetising force of the fixed coils on the magnets. Thus, if we know the lead of the brushes and the current in the armature, we are at once in a position to calculate the effect on the E.M.F. of the machine. A further effect of the current in the armature is a material disturbance of the distribution of the induction over the bored face of the pole-piece; the force along B C is by no means equal to that along D E. Draw the closed curved B C G H B, the line integral along C G, and H B is negligible. Hence the difference between force H G and B C is equal to $4\pi C \frac{m}{2} \frac{\kappa}{\pi} = 2\kappa m C$, where κ is the angle C O G."

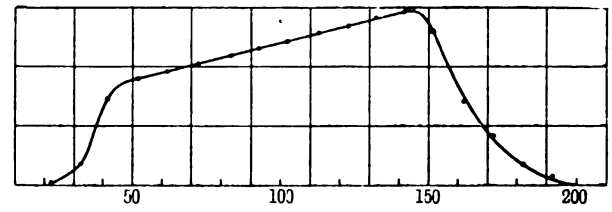

FIG. 3.—No. 1 as Dynamo.

To verify this formula is one of the principal objects of this Paper.

A pair of brushes having relatively fixed positions near together, and insulated from the frame and from one another, are carried upon a divided circle, and bear upon the commutator. The difference of potential between these brushes was measured in various positions round the commutator, the current in the armature, the potential difference of the main brushes, and the speed of the machine being also noted.

The results are given in Figs. 3, 4, 5, and 6, in which the ordinates are measured potential differences, and the abscissæ are angles turned through by the exploring brushes. The potential differences in Fig. 3 were measured by a Siemens voltmeter, and each ordinate is, therefore, somewhat smaller than the true value, owing to the time during which the exploring brushes were not actually in contact with the commutator segments. But this does not affect the results, because the area is reduced in the same proportion as the potential differences. In Figs. 4, 5, and 6 the potential differences were taken on one of Sir William Thomson's quadrant electrometers, and are correct.

Take Fig. 3, in which machine No. 1 is a generator. A centimetre horizontally represents 10 degrees of lead, and the ordinates represent differences of potential between the brushes.

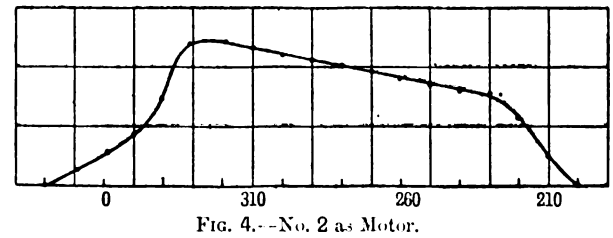

FIG. 4.—No. 2 as Motor.

The area of the curve is 61·3 sq. cm, and represents 130 volts and a total field of $\frac{130}{104} \times \frac{1}{29} \times 10^8 = 4{\cdot}31 \times 10^6$ lines of induction. This is, of course, not the actual field, which is 3 per cent. greater on account of the resistance of the armature, but is represented by an area 3 per cent. greater. An ordinate of 1cm. will represent an induction of $\frac{4{\cdot}31}{61{\cdot}3} \times 10^6 = 7{\cdot}0 \times 10^4$ lines in 10deg. The area of 10deg. is $39{\cdot}5 \times 1{\cdot}73 = 68{\cdot}3$sq.cm.*

* In calculating this area, the allowance for fringe at ends of armature is taken less than before, because the form of opposing faces differs.

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Hence, an ordinate of 1cm. represents an induction of 1,024 lines per square centimetre. The difference between ordinates at 50deg. and 140deg. is 2·5; hence the difference of induction is actually 2,560. Theoretically, we have $\kappa = \frac{1}{2}\pi m = 104$ C = 9·4. Therefore, $2\kappa m$ C = 3,072, and this is the line integral of magnetising force round curve.

Let A be the induction at 50deg., and A + δ at 140deg.: these also are the magnetising forces. Hence, (A + δ) 1·4 − A 1·4 = $2\kappa m$ C; δ = 2,200 as against 2,560 actually observed.

Take Fig. 4, in which No. 2 machine is a motor. The total field $= \frac{107}{104} \times \frac{1}{20} \times 10^8 = 5{\cdot}15 \times 10^6$ lines of induction. Since the area of the diagram is 53·5 sq. cm., an ordinate of 1cm. $= \frac{5{\cdot}15}{53{\cdot}5} \times 10^6 = 96 \times 10^4$ lines of induction in 10deg. Hence,

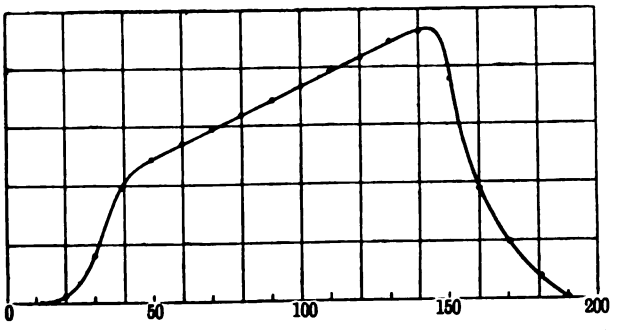

Fig. 5.—No. 1 as Dynamo.

an ordinate of 1cm. represents an induction of $\frac{9{\cdot}6 \times 10^4}{68{\cdot}3}$ = 1,400 lines per sq. cm. The difference between ordinates at 320deg. and at 230deg. is 2·0; hence, the difference of induction is actually 2,800. Theoretically we have $\frac{2\kappa m \text{C}}{l}$ $= \frac{3\frac{1}{2} \times 104 \times 11{\cdot}4}{1{\cdot}4} = 2{,}666$, as against 2,800 actually observed.

In Fig. 5 No. 1 machine is a generator. The total field $= \frac{52}{104} \times \frac{1}{12{\cdot}6} \times 10^8 = 3{\cdot}97 \times 10^6$ lines. The area of the diagram is 90·9 sq. cm., and therefore an ordinate of 1 cm. $= \frac{3{\cdot}97}{90{\cdot}9} \times 10^6 = 4{\cdot}37 \times 10^4$ lines in 10deg. Hence, an ordinate of 1 cm. represents an induction of $\frac{4{\cdot}37 \times 10^4}{68{\cdot}3} = 639$ lines per sq. cm. The difference between ordinates at 50deg.

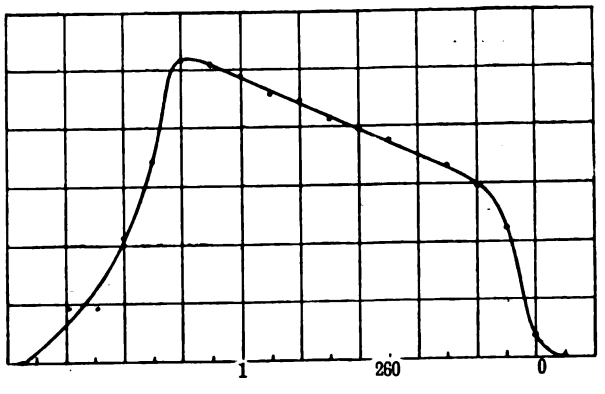

Fig. 6.—No. 2 as Motor.

and at 140deg. is 4·5; hence, the difference of induction is actually 2,877. Theoretically, we have $\frac{2\kappa m \text{C}}{l} = \frac{3\frac{1}{2} \times 104 \times 12{\cdot}9}{1{\cdot}4}$ = 3,010, as against 2,877.

In Fig. 6 No. 2 machine is a motor. The total field = $\frac{63{\cdot}5}{104} \times \frac{1}{12{\cdot}3} \times 10^8 = 4{\cdot}96 \times 10^6$ lines. The area of the diagram 112·2 sq.cm., and therefore an ordinate of 1cm. $= \frac{4{\cdot}96}{112{\cdot}2} \times 10^6$ $= 4{\cdot}42 \times 10^4$ lines in 10deg. Hence, an ordinate of 1cm. represents an induction of $\frac{4{\cdot}42}{68{\cdot}3} \times 10^4 = 647$ lines per sq. cm. The difference between ordinates at 323deg. and at 233deg. is 4·2; hence, the difference of induction is actually 2,718. Theoretically, we have $\frac{2\kappa m \text{C}}{l} = \frac{3\frac{1}{2} \times 104 \times 12{\cdot}3}{1{\cdot}4} = 2{,}870$, as against 2,718 actually observed.

At page 345 of the Paper on Dynamo-Electric Machinery it is shown that

$$\text{I} + \frac{\nu - \text{I}}{\nu} 4\lambda m \text{C} \frac{\text{A}_2}{2 l_2} = \text{F}\left(4\pi n c - \frac{4\lambda m \text{C}}{\nu}\right),$$

where I = F $(4\pi n c)$ is the characteristic curve when C = 0, and λ is the lead of the brushes.

The following is an endeavour to verify this formula. The potentials both upon the magnets and upon the brushes were taken by a Siemens' voltmeter, and are rough. The speeds were taken by a Buss tachometer, and there is some uncertainty about the precise lead of the brushes, owing to the difficulty in determining the precise position of the symmetrical position between the fields, and also to the width of the contacts on the commutator.

It was necessary, in order to obtain a marked effect of the armature reaction, that the magnet field should be comparatively small, that the current in the armature should be large, and the leads of the brushes should be large.

The two machines had their axles coupled so that No. 1 could be run as a generator, and No. 2 as a motor. The magnets were in each case coupled parallel, and excited by a battery each through an adjustable resistance. The two armatures were coupled in series with another battery, and the following observations were made:—

—	Potential on magnets in volts.	Potential on brushes.	Speed per minute.	Current in amperes.	Lead of brushes.
No. 1	24—24	66—67	880	102—103	26°
No. 2	29—29	86—84	880	102—103	29°

From which we infer:—

—	Current in magnets.	$4\pi n c$.	Corrected potential for resistance of armature.	Total induction I.
No. 1	1·78	8,900	70·8	$2{\cdot}30 \times 10^6$
No. 2	2·15	10,750	80·7	$2{\cdot}65 \times 10^6$

As there was uncertainty as to the precise accuracy of the measurements of potential, it appeared best to re-measure the potentials with no current through the armature with the Siemens' voltmeter placed as in the last experiment. Each machine was, therefore, run on open circuit with its magnets excited, and its potential was measured.

—	Potential on magnets in volts.	Potential on brushes.	Speed per minute.	Potential at 880 revs.
No. 1	25—25	90—90	880	90·0
No. 2	28—28	79—80	715—710	98·2

From which we infer, since we are upon a part of the characteristic which is practically straight; in which case, of course, the formula is reduced very nearly to

$$\text{I} = \frac{\text{A}_2}{2 l_2}(4\pi n c - 4\lambda m \text{C}).$$

—	Potential on magnets.	Potential on brushes.	Induction I = F$(4\pi n c)$.
No. 1	24	86·4	$2{\cdot}82 \times 10^6$
No. 2	29	101·7	$3{\cdot}30 \times 10^6$

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We have further :—

$\lambda = 0{\cdot}45$ for No. 1. $\lambda = 0{\cdot}5$ for No. 2.

$\frac{4\,m\,C}{\nu} = 2{,}920.$ $\frac{\nu - 1}{\nu} 4\,m\,C\,\frac{A_2}{2l_2} = 443{,}800.$

It has already appeared that experiment gives for I in No. 1 $2{\cdot}3 \times 10^6$, and in No. 2 $2{\cdot}65 \times 10^6$. The difference is probably due to error in estimating the lead of the brushes, which is difficult, owing to uncertainty in the position of the neutral line on open circuit.

—	$\frac{4\lambda m C}{\nu}$.	$\frac{\nu-1}{\nu} 4\lambda m C \frac{A_2}{2l_3}$.	$4\pi nc - \frac{4\lambda m C}{\nu}$.	$F\left(4\pi nc - \frac{4\lambda m C}{\nu}\right)$.	$F\left(4\pi nc - \frac{4\lambda m C}{\nu}\right) - \frac{\nu-1}{\nu} 4\lambda m C \frac{A_2}{2l_2}$.
No. 1 ...	1314	199700	7586	$2{\cdot}41 \times 10^6$	$2{\cdot}21 \times 10^6$
No. 2 ...	1460	22.900	9_90	$2{\cdot}90 \times 10^6$	$2{\cdot}68 \times 10^6$

LOAD DIAGRAMS OF ELECTRIC TRAMWAYS, AND THE COST OF ELECTRIC TRACTION.*—By A. Reckenzaun.

(*Concluded from page 579.*)

The Americans, as you are well aware, are far ahead of us in matters relating to tramways; they count their electric roads by hundreds, and their electric cars by thousands. I need not enlarge here upon figures well known to all readers of engineering literature, but I venture to point to recent statistics on working expenses, and especially to those prepared by Mr. J. S. Badger for the Street Railway Convention last October when meeting at Pittsburgh. Mr. Badger gave an immense amount of data, all systematically arranged, of which Table V. is an abstract, converted into Eng.ish equivalents as to money values. Those interested in all its details will find a reprint of this elaborate communication in the *Electrical World* of October 31, 1891. Indeed, in order to fully appreciate the data contained in Table V., certain descriptive matter should accompany it; and this deals with the number and sizes of boilers, engines, dynamos, the quality and price of coals, condition of road and track, sizes and number of cars, total mileage, and wages in various localities. I merely give the most essential ones.

Road No. 1 has a generating station containing four boilers, one 250 H.P. Corliss engine, one 150 H.P. Ball engine, one 150 H.P. Brown engine, and two Edison generators. The line runs through five miles of streets, and the steepest gradient is 13·2 per cent., 100ft. long. There are 36 motor cars of the ordinary size, of which 20 are in daily use, making annually 601,966 miles. The price of coal is 8s. 4d. per ton, and the consumption 7lb. per car mile.

Road No. 2: Four boilers, two Taylor-Beck engines of 125 H.P. each, one of 175 H.P., one Armington and Sims of 250 H.P.; five Edison dynamos. Track, six miles long; steepest gradient, 9·25 per cent. for 400ft. 18 motor cars, of which 16 are in daily use, making an annual mileage of 724,000. Price of coal, 7s. 3d. per ton; consumption, 11lb. per car mile.

Road No. 3: Eight boilers; nine steam engines, of which five are of 125 H.P. and two 100 H.P., all of the Phœnix type; also two 125-H.P. Beck engines. Nine Edison and seven Thomson-Houston dynamos supply current for 50 motor cars in daily use, making an average of 1,819,000 miles per annum. There are altogether 53 motor cars, of which four were supplied by Westinghouse, 20 by Edison, and 29 by the Thomson-Houston Company. Steepest grade, 8 per cent. for 800ft.; total length of streets traversed, 35 miles. Cost of coal, 11s. 2d.; and the consumption of fuel is calculated to be 12·2lb. per car mile.

Road No. 4: Two boilers and three 150-H.P. Ball engines, driving six dynamos. Length of streets run through, 14 miles, with 18 motor cars, making annually 700,000 miles. There is one steep gradient of 10 per cent. rise for 775ft. Coal, in this case, costs 8s. 9d., and the amount used per car mile is only 6·4lb.

The fifth road, out of seven given by Mr. Badger, is only four miles long, with five passenger cars and one freight car. It has only been running for nine months up to the date of the report. The coal costs 12s. 8d. to 15s. 10d. per ton; water, 5d. per 1,000 gallons. The wages on all the above lines varied between 40s. and 60s. per week for drivers, conductors, and mechanics.

The most important of all the American electric tramways is that of the West End Railway Company of Boston, where they have now 400 electric cars in operation. Table VI. gives a comparative statement of gross receipts and working expenses of the electric cars and horse cars in the city of Boston for five months ending August, 1891. No detailed account is given, but the rolling stock is continually being increased, and the central-power station in course of construction will contain engines capable of converting 12,000 H.P. into electrical energy. All the American lines referred to are worked on the overhead conductor principle.

I have intentionally omitted comparisons between electric traction and various modes of mechanical traction, such as cable, steam, and compressed air. Our object in this Institution is to inquire into the merits of systems involving the use of electricity, and to further their extension in every legitimate way, and with this point in view I have endeavoured to collect and bring before you such data as may tend to increase the general interest in one important branch of our profession.

* Paper read March 24, 1892, before the Institution of Electrical Engineers.

Table V.

Working Expenses of Five Representative American Electric Tramways.

—	Road 1. Per car mile.	Road 2. Per car mile.	Road 3. Per car mile.	Road 4. Per car mile.	Road 5. Per car mile.
Permanent Way.	d.	d.	d.	d.	d.
Maintenance of road-bed and track	0·225	0·335	0·475	0 085	0·050
Maintenance of line	0·035	0·075	0·100	0·105	0·030
Maintenance of Power Plant.					
Repairs of engines and boilers	0·018	0·055	0·195	0·013	0·036
Repairs of dynamos	0·008	0·007		0·013	0·008
Miscellaneous repairs		0·118		0·019	0·004
Cost of Power.					
Fuel	0·335	0·483	0·822	0·345	1·073
Wages at generating station	0·296	0·186	0·212	0·196	0·437
Oil and waste	0·032	0·077	0·102	0·029	0·109
Water*	0·046	0·035		0·027	0·147
Other supplies	0·005	0·010		...	0·116
Maintenance of Rolling Stock.					
Machine shops, and repairs to motors & cars	0·922	0·414	1·503	1·162	0 293
Transportation Expenses					
Wages of conductors and motor men	2·318	1·778	2·236	2·516	1·826
Miscellaneous wages for inspectors, trackmen and cleaners	0·525	0·159	0·095	0·018	1·234
Accidents to persons and property	0·013	0·053	...	...	0·003
General Expenses.					
Insurance	0 766	0·094	0·230	0·036	0·084
Salaries, &c.		0·324		0·272	0·685
Office expenses	0·021	0·014	0·081	..	0·035
Advertising, printing, legal and miscellaneous expenses	0·035	...	0·094	0·693	0·131
Total expenses per car mile	5·601	4·217	6·145	5·529	6·301

Table VI.—West End Railway Company of Boston.

Working Expenses for Five Months ending August, 1891.

	Electric traction.	Horse traction.
Gross receipts	£29,337 6	£78,779 4
Track and car expenses	9,030 8	26,729 6
Motive power	5,733 0	23,949 0
Total operating expenses	16,274 2	55,043 4
Miles run	375,474·8	1,093,808·2
Ratio of mileage	25·75 %	74·25 %
Ratio of operating expenses	55·47 %	69·87 %
Total expenses per mile run	10·41d.	12·06d.
Gross receipts per mile run	18·76d.	17·26d.

AUTHORISED ABSTRACT.—March 24, 1892.

Mr. MACMAHON, of the City and South London Railway Company, had not found such large variations of the volts as Mr. Reckenzaun mentioned. In his own practice he had occasionally found as much as 130 volts variation when running his dynamos simple-shunt, or when the belt slipped; but when running compound the maximum range was from 420 to 500. Mr. Reckenzaun's curves were obtained from readings taken every five

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seconds; if they had been taken by a recording instrument they would, he thought, have been found very much more rounded; the tops of the peaks being often quite flat for two seconds together. The current curve of a line when eight cars are on at once, he had found to show comparatively moderate variations, say, from 100 to 300 A, and never dropping below 80. When the number was reduced to five cars the current was very irregular and frequently dropped to zero. With ten or more cars, and volts varying proportionately to what they now do for five cars, he thought the average variation would not exceed 10 per cent. He did not believe in the use of accumulators as steadiers, and considered them as rather a nuisance.

Mr. M. VOLK said it was desirable to equalise the load on the engine as far as possible, as it was very uneconomical to have the latter several times more powerful than was required for the average load. He said that at Brighton he had a one-ton fly-wheel running at 160 revolutions on a 12 H.P. engine, and was able to start two cars at once; whereas, with a light fly-wheel, the attempt would have pulled the engine up. The cost at Brighton was about 4d. per car mile, running 23,000 car miles per annum. It was an edge-rail track, and required less power.

Mr. GRAFF BAKER, of the Thomson Houston Company, said that the German figures in the Paper were new to him. Mr. Reckenzaun had referred to the low cost of labour there as compared to America. How did the cost of labour and fuel in Germany compare with that in England? In putting down a plant in England, the data obtained from American experience had to be much modified. He had obtained from America a motor which had given very good results there, and had found that it was not nearly so satisfactory in Leeds, where he used it in November on different rails and muddy streets. He employed a large staff to investigate the results, and ascertain the differences of the conditions compared with American practice. His expenses were, therefore, much greater than those of a purely commercial line. On this account he hesitated to give the figures that Mr. Reckenzaun had asked for without prefacing them with the explanation of how it was that they were so much in excess of the American ones, where everything was cut and dried. The following costs per car mile were obtained from an average fortnight's run. General expenses (salaries, office expenses, &c.) 1·13d., transport expenses (including drivers, conductors, and inspectors), 5·17d., maintenance of equipment 0·33d. He had some difficulty in getting a competent staff accustomed to motors, and had been obliged to get two men at high wages from America to instruct them; his head engine driver alone got £3. 10s. per week. Their engine, too, was running much under its full load (a 200 H.P. engine running at 75 H.P.). Five cars were plenty to do the work all the week, but on Saturday and Sunday 50 or 60 would not be too many. He sometimes had 116 people on a 60ft. car. The maintenance was principally for new wheels, the original ones not being suitable for Leeds.

Mr. STUART RUSSELL showed a diagram of currents on the Hague-Schevening* line. Outside the town, running at about 14 miles per hour

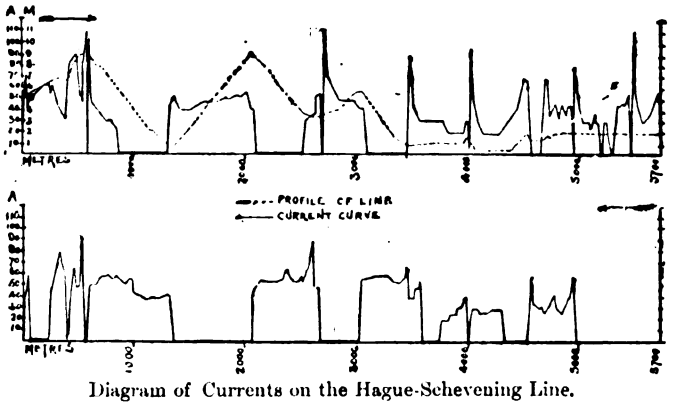

Diagram of Currents on the Hague-Schevening Line.

on T-headed rails, the tractive force on a straight level was about 20lb. per ton. In towns the speed was seven miles per hour. The cars weighed 17 tons (including batteries and passengers); 200 cells were used, two in parallel in town, and all in series outside. Each run (about 30 minutes) required about 20 ampere hours, of which 9 ampere hours were expended in starting from rest and getting up to normal speed. The starts averaged five or six per mile. The average H.P. over the run out and back was about 13. In reply to Mr. Kapp that 17 tons per car was exceptionally heavy, Mr. Russell said that this included 200 cells and 60 passengers.

Mr. DOLBY thought that a great deal of power was lost in starting from rest with a rigidly geared motor, and thought it would effect a great saving if the motor were allowed to attain its normal speed, and were then put on by friction gear with considerable slip at first.

Mr. MANVILLE thought that the engine might be spared a good deal of strain by the use of a set of accumulators; not the ordinary expensive type but plain lead plates; these would charge when the load suddenly dropped and would help the engine for a short time when a number of cars were started at once. Electric trams would, he said, never be really successful as long as a clause for the protection of the telephone companies prevented the use of earth return. It was practically impossible to run a two-wire overhead line. A Birmingham Company had dropped their Bill on account of being unable to get the clause omitted. In America they recognised the principle that the roadways were first of all for traffic.

Mr. RUSSELL wished to know the weight of the Thomson-Houston cars.

The discussion was adjourned.

* For full description of this line, see *The Electrician*, November 20, 1891, p. 66.

PHYSICAL SOCIETY.

At a meeting of this Society on March 25, 1892, Prof. S. P. THOMPSON, Vice-President, in the Chair, a Note

"On the E.M.F.'s of Gold and Platinum Cells"

was read by Prof. E. F. HERROUN. The few experimenters who have tested such cells arrived at different conclusions; hence the author examined experimentally zinc-platinum and zinc-gold cells, the metals being immersed in solutions of their chlorides of equal molecular strength. From Thomson's thermo-chemical data, the E.M.F. of such a zinc-platinum cell should be 1·548 volts, whilst experiments gave values between 1·70 and 1·473 according to the previous history of the cell. This high value, and the uncertainty of the E.M.F. after sending a current, the author believed due to dissolved oxygen. Other experiments showed that gold is slightly electropositive to platinum in water or dilute HCl., but in *aqua regia* the positions are reversed.

DISCUSSION.

Prof. AYRTON said the experimental E.M.F.'s were fairly close to the theoretical values, and thought the differences might arise from occlusion of gases, which, although not taken into account in the thermo-chemical experiments, might have considerable effect on the electrical values. Platinum especially had remarkable occluding properties.

The CHAIRMAN (Dr. Thompson) believed that some discrepancy between the calculated and observed values of the E.M.F.'s might be due to the calculations only being carried to the first degree of approximation. The complete expression contained, amongst others, a term depending on the temperature co-efficient of the cell.

Dr. HERROUN, in reply, said care was taken to expel as much of the occluded gas as possible before using the plates, and no gases were formed in the re-actions. To Dr. Thompson he pointed out that Clark's cell had an E.M.F. greater than that calculated from thermo-chemical data; hence the temperature coefficient ought to be positive, but as a matter of fact it was negative. The discrepancy between the calculated E.M.F. and the observed he believed due to inaccurate determinations of the thermo-chemical constants of mercury salts.

A Paper on

"Some Electrical Instruments,"

was then read by Mr. R. W. PAUL, a full report of which will be found in our last issue.

DISCUSSION.

Mr. SWINBURNE inquired whether the plan of using two vertical magnets to form an astatic system had been tried, and with what result. He also asked if dial bridges made with switches instead of plugs would not be advantageous.

Dr. SUMPNER said vertical needles had been used at the Central Institution and found satisfactory.

Mr. A. P. TROTTER wished to know for what purpose the galvanometer was intended, since it appeared that the coils were wound with a minimum amount of wire. A galvanometer was often required for many different purposes, and it did not follow that one with a minimum amount of wire was the best all-round instrument.

Mr. C. W. S. CRAWLEY made inquiries as to the magnitude of the block error in the form of the Wheatstone bridge shown, for he thought the flexible cords would make it considerable. In reply to Mr. Swinburne he said he had found the variations in switch bridges greater than in plugs.

Prof. S. P. THOMPSON thought it was not generally known that the best shape of galvanometer coil depended on whether the instrument was to be used as an ammeter or voltmeter. The shape determined by Sir W. Thomson was a voltmeter coil; that for an ammeter was much shorter axially.

Mr. PAUL, in reply, said he used one or other shape of coil according to the use for which the galvanometer was intended. The block error in the Wheatstone bridge was very small and quite negligible for most purposes. When very great accuracy was required the error, being constant, was easily measured and allowed for.

LEGAL INTELLIGENCE.

King, Brown and Co. v. the Anglo-American Brush Electric Light Corporation.

JUDGMENT.

In the House of Lords, on Tuesday, their Lordships delivered judgment in this case. The appellants carried on business at No. 6, York-place, Edinburgh, and the respondents at the Rosebank Electric Works, Broughton-road, Edinburgh; and the question raised was whether the letters patent, No. 2,003 of 1878, granted to Mr. Herbert John Haddan, for an alleged communication from Mr. Charles Brush abroad, and twice amended and disclaimed, were invalid. The Judges of the First Division of the Court of Session, Edinburgh, held that the patent was invalidated in its essential and fundamental privilege, by reason of the prior publication and prior use by Mr. Samuel Alfred Varley of the invention of compound winding, for which the exclusive privilege was given, and they affirmed the Lord Ordinary's interlocutor. The Anglo-American Brush Electric Light

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Corporation appealed to their Lordships against that decision, and the appeal was heard at the end of last year, when judgment was reserved.

The Attorney-General (Sir R. Webster, Q.C.) Mr. Moulton, Q.C., and Mr. Graham appeared for the appellants; while the Solicitor-General for Scotland (Mr. A. Graham Murray, Q.C.), and Mr. A. Daniell opposed it on behalf of the respondents.

The LORD CHANCELLOR, in delivering judgment, said: This is an appeal against an interlocutor of the First Division of the Court of Session, affirming the interlocutor of the Lord Ordinary, setting aside the patent, of which the appellants are the assignees, on the ground that the portion of the invention patented (with which, under the circumstances, it is alone material to deal) had been previously published. The patent to set aside is known as Brush's patent, and bears date November 16, 1878; and the question in debate is whether a patent taken out by Mr. Samuel Alfred Varley in 1876 does or does not so anticipate the patent of 1878, of which the appellants are the assignees, as to make the latter patent bad. The patent has relation to the particular form of dynamo-electric machines, all of which have, and were known to have before the date of either patent, this principle in common, that they move magnets past coils of wire or coils past magnets, with sufficient velocity to produce the desired result. It was also familiar knowledge before the date of either patent that a current of electricity sent round a bar of soft iron would render the bar of iron magnetic. Undoubtedly, the progress of electrical science has given rise to various forms of using the energy, in which the two principles to which I have adverted have become important, and the practical application of them by means of different mechanical devices has for some time past exercised the ingenuity of practical electricians. One appears to have been the idea of making one wire go round the iron bar, make it and maintain it as a magnet, making the same wire go to perform whatever work it was intended to perform, and returning to the magnet, the single current thus doing two things. The further step was made when what was called the shunt apparatus was invented. The current of electricity was divided into two. One stream, so to speak, was made to go round the iron bar, keeping it magnetic, while the other was led to do the work which it was required to do, and were re-joined after the work had been accomplished. Mr. Imray explains with great clearness what are the two principles called series and shunt-winding. On the machine being revolved, he says, a wire wrapped round and round the magnet crosses over to another magnet, proceeds to do whatever work is required of it in what is called the external or working circuit, and goes back again after doing the work. It is called "series" winding, because the coils of the electro-magnet are in series with the external circuit; that is to say, it is one continuous wire. The current goes straight from start to finish. The whole electricity produced by the machine goes to excite the magnet and to the external wire, and straight from the one to the other. The weak point of it (said Mr. Imray) is this: that as soon as you break the external circuit you will cease to have an electric machine, because there is no current. In electrical language, that is spoken of as having the external circuit opened. When the external circuit is broken or opened, the current ceases to flow, and you do not have the advantage of any magnetising action by the current going around the magnets of the machine. In the same way, the more resistance you put in your external circuit, that is to say, the more work you ask your machine to do, the less current will flow through the external circuit; and the more work you have, the less you will be doing towards the magnetising of your machine. Resistance in wire mainly depends: first, upon the character of the wire and what metal it consists of; secondly, upon its transverse section; and, thirdly, upon its length. The longer the wire the greater the resistance; the smaller the section the greater the resistance; one kind of metal has more resistance than another. Roughly speaking, a short thick wire has much less resistance than a long thin one. Another form is what is called "shunt-winding," in which the difference is simply in the disposition of the wires. The current coming away, is split into two. One portion of it goes to what has been called the external circuit, doing whatever is to be done, and having done that work returns to the machine, but without any actual contact with the magnets of the machine at all. The other portion goes straight to the magnet, is wrapped round it as before, and then returns to the brush, as it is called, without any contact with the external circuit at all. The strong point (says Mr. Imray) of this arrangement is that, whether the external circuit is open or closed, there is always magnetism in the wire capable of producing electricity, because the current is continually running through the shunt to the magnet. A defect in it is that some of the electricity is taken away from the external circuit which otherwise would go through it. One further explanation of Mr. Imray's becomes necessary to follow the question with which your Lordships have to deal, and that has reference to what Mr. Imray says is variously known as "electromotive force," "tension," "pressure," and "potential." "Potential" seems to be the word generally used, and means the intensity of pressure by which the electricity is caused to pass along a conductor. The advantage of what is called a compound winding, which is neither more nor less than a combination of the two previously described, the first being known as "series," the second as "shunt," and the one in debate as "series-shunt," or compound winding. The advantage of the arrangement is in producing a constant pressure, or an equal volume, or an even current. It is difficult, except by finding analogies in other subjects of physical research than electricity, to convey the exact idea, but the advantage attained, at all events, is that when the work is changed in the outer circuit the amount of current that goes round the magnet is so changed that one compensates, or nearly compensates, for the other.

Now in the patent, patented in 1876, Mr. Varley says:—"Part of the electricity developed by the machine is *diverted*" and the word is significant) "to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light. There are several well-known ways of doing this" (this has been the subject of very violent comment), "but the method I prefer is to wrap the soft iron magnets with two insulated wires, one having a *larger* resistance than the other. The circuit of larger resistance is always closed, and the circuit of *less* resistance used for the electric light. When the electric light is being produced the greater portion of electricity passes through the circuit of less resistance which I term 'the electric light circuit,' maintaining the magnetism of the magnets and producing the light. When the electric light circuit is opened from any cause, the electricity developed passes through the circuit of greater resistance only, and maintains the magnetism of the magnets." It is impossible to deny that in the present state of electrical knowledge dealing with dynamos but that the description given undoubtedly does disclose to anybody familiar with the principle of electro-dynamos and the medium by which the electric current is turned to account, points to the very thing for which the patent was granted to Mr. Brush. But it is said that, for the purpose of judging of the novelty of the invention of 1876, one must, as nearly as one can apply oneself to the knowledge existing at that date, and not apply what we have learned since, so as to interpret the language of the patent of 1876 by the light of later discoveries. I am not quite certain that I understand the application to this case of that principle of interpretation, which, however, I admit to be sound. The "series" was known, the "shunt" was known, and the language seems to me incapable of any other interpretation than that the patentee did mean to combine the two previously known systems. If he did, and disclosed the mode of doing it, the novelty of the later patent cannot be supported. I confess that I am unable to entertain a doubt that it was so disclosed. What he intended was, I think, conclusively shown by the original rough sketch produced. Distinguished electricians cavil at the mode of its disclosure, criticise the language (which is not, perhaps, the most felicitously chosen), and possibly suggest doubts as to what would have been the fate of Mr. Varley's patent if it had been attacked upon the ground of the insufficiency of the specification; but that is not the question to be determined here. The question is the disclosure of the invention, which consisted in the combination of two known forms of dynamo-electric machines. I doubt whether there is much to choose in clearness of exposition between the one patent and the other. I think it is certain that neither the one patentee nor the other had any very definite notion of the importance of the invention until a year or two later. The invention of the incandescent light brought into prominence the importance of an even, uniform, and continuous flow of the electric energy. I am, therefore, of opinion that the interlocutor appealed from ought to be affirmed.

I have confined myself, however, in arriving at this conclusion to the specifications themselves, aided by scientific witnesses, in interpreting the scientific nomenclature in which the specifications are couched, and the explanations of the witnesses as to the operations produced by the different forms adopted. I designedly avoid giving any opinion upon the question of the user of Varley's machine. Many questions, to my mind, arise as to which publication there was from the use of that machine, as a machine disclosing the mode by which the electric light was produced. But inasmuch as I have come to the conclusion that I have indicated, it is not necessary further to discuss the extent to which the use of the electric light by means of Varley's machine for the purpose of illustrating some submarine invention, was such an exhibition or publication of it as would make a subsequent patent void. I therefore move your Lordships, that the interlocutor appealed from be affirmed, and this appeal dismissed with costs.

LORD WATSON said: The applicants are assignees of Brush's patent of 1878, for improvements in apparatus for the generation and application of electricity for lighting, plating, and other purposes. The patent originally included two different dynamo-electric apparatus, now known respectively as the shunt and the series-shunt; but in 1882, the appellants, having become aware of the fact that their shunt-winding machine had already been fully described and claimed in Clark's Patent of 1875, amended their specification by disclaiming that part of it which related to shunt winding, and limiting their claim to the series shunt. In this appeal they complain of a decision of the First Division of the Court of Session, affirming an interlocutor of the Lord Ordinary (Trayner), by which he reduced and set aside their letters patent as amended by disclaimer, on the grounds, *inter alia*, that the series-shunt apparatus therein described had been published in Varley's patent of 1876, and also that there had been prior public user. Dynamo-electric machines are useful for various kinds of work, but are now chiefly employed for producing light. I shall, in so far as it may be necessary to describe such machines, refer to them as if they were used for the latter purpose. At the date of Clark's patent, the only known variety of self-exciting dynamos was the series-winding apparatus, in which the current of electricity generated in the revolving coils after it was passed through the commutator, is conducted to and round the magnets and thence to the lamps, from which it returns to the machine, thus forming a single electric circuit, which performed the double function of magnetising the magnets and doing work. In the shunt apparatus, the volume of electricity, after it has passed the commutator, is divided into two unequal currents by means of a shunt, or bifurcation of the conducting wire, which is, in itself, a common device. The smaller current is then made to circulate round the magnets, whilst the larger is led to the lamps; and they are again united, just before they re-enter the machine. So that these currents form two separate circuits, that of greater resistance maintaining the supply of electric force in the magnets, and that of lesser resistance producing light. The series-shunt-winding apparatus is, as its name imports, a combination of the two systems already described. Its arrangements are practically the same with those of the shunt-winding machine, subject to this modification, that after bifurcation, the larger current, instead of being taken direct to the lamps, is, in the first instance, made to encircle the magnets. Accordingly, the smaller current serves for excitation only, as in the shunt system; whereas the larger current serves both for excitation and for work, as in the series-winding system. Whether the series-shunt system was first disclosed to the public by

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Varley in 1876, or by Brush in 1878. it seems to be certain that the real merit of the arrangement was neither understood nor appreciated until the subsequent discovery of the incandescent lamp. The efficiency of that mode of lighting depends upon the light produced by the incandescent filaments of carbon, and the maintenance of a uniform and steady flow of electricity in the working circuit, which is now termed a constant potential. In the series, and also in the shunt system, the working current is liable to considerable variation; with this difference, that the same disturbing elements which in the one case cause a decrease, in the other occasion an increase of E.M.F. The combination of these opposite tendencies brings into play the principle of compensation, and makes it possible, by careful adjustment, to attain a more constant potential with the series-shunt than with either of its component systems.

The terms of Brush's specification indicate that the patentee had not in his view the attainment of that high degree of constancy in the motive force which is desirable for the purpose of incandescent lighting. He points out that other machines were "not well adapted for certain kinds of work, notably that of electro-plating," and then proceeds to describe his own in these terms:—"I attain my object by diverting from external work a portion of the current of the machine, and using it either alone or in connection with the rest of the current for working the field magnets. I prefer the latter plan of the two, especially for electro-plating machines." In other words, he attains his object by using either the shunt or the series-shunt, but prefers the latter for electro-plating. For other purposes than electro-plating, he does not suggest that the one system is in any respect greatly preferable to the other. As matter of fact, it appears to be doubtful which of the two is most suitable for plating. Mr. Preece, one of the appellants' skilled witnesses, says: "Pure shunt is preferred in England for electro-plating. In America the compound is preferred."

In Varley's patent of 1876 no claim is made either for shunt or for series winding. The passage which has been held, by both Courts below, to anticipate the invention claimed by the appellants is merely descriptive of the machines to which the arrangements claimed by Varley may be usefully applied, and is in these terms: "Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft-iron magnets, and the remaining portion is used to produce the electric light. There are several well-known ways of doing this, but the method I prefer is to wrap the soft-iron magnets with two insulated wires, one having a larger resistance than the other. The circuit of larger resistance is always closed, and the circuit of less resistance is used for the electric light. When the electric light is being produced, the greater portion of electricity passes through the circuit of less resistance. which I term 'the electric light circuit,' maintaining the magnetism of the magnets, and producing light. When the electric light circuit is opened, from any cause, the electricity developed passes through the circuit of greater resistance only, and maintains the magnetism of the magnets." In estimating the real significance of Varley's specification, it is necessary to consider what amount of information with respect to dynamo-electric apparatus ought to be attributed to persons who had an opportunity of reading it in the year 1876. The language used by the patentee must be construed with reference to the information then open to the public, and not in the light of subsequent discoveries. To my apprehension, it does not admit of doubt that a reader, acquainted only with series-winding, might not attach the same meaning to the words used by Varley, as would naturally occur to one who was also familiar with the shunt, or with the shunt and series-shunt systems of winding.

Since the hearing of this appeal, I have carefully perused the whole evidence adduced by both parties, in so far as it has any bearing upon the issue of prior publication. Of the respondents' evidence it is sufficient to say that it is in entire accordance with the decision appealed from. The appellants' evidence consists of oral testimony by electricians of great eminence, and is directed mainly, if not wholly, to prove (1) that, on a fair construction of the specification of 1876, the words relied on by the Court of Session do not disclose either shunt or series-shunt winding, and (2), assuming them to do so, that the specification does not contain explanations or directions which would enable a workman of ordinary skill to construct either a shunt or a series-shunt machine. I need hardly say that it is for the Court, and not for the witnesses, to construe the terms of the specification; and that their evidence upon the first of these points is only material in so far as it may supply scientific facts which ought to be taken into account in arriving at the true construction of the instrument. There is one circumstance which, in my opinion, seriously affects the value of the appellant's evidence on both points. The testimony of their witnesses was given upon the footing that, in 1876, Clark's invention of the previous year was still unknown, and that those who read Varley's specification could have no knowledge of any system other than series winding. Upon that assumption it occurs to me that a reader, whether a man of science or skilled workman, would probably have been at a loss to discover what Varley meant, and might not have arrived at either shunt or series-shunt winding without some exercise of his inventive faculty. I am, however, unable to find any good reason for holding that Clark's shunt machine was unknown in the year 1876. It is true that in 1878 Mr. Brush had never heard of Clark's invention, and also that shunt winding was unknown to Sir W. Thomson before 1879. But it appears to me that Clark's taking out a patent for his invention was, both in fact and law, a publication of it. I do not suppose that every electrician, however eminent, is by necessity personally cognisant of every invention patented within the bounds of his science; and the ignorance of two or more of them is unavailing to prove that the knowledge of others was equally defective. I cannot, therefore, avoid the conclusion that, in 1876, Clark's shunt-winding machine had been disclosed to the public, and must have been known to some, if not to all, electricians; and, consequently, that the uncontroverted passage in Varley's specification ought to be construed on the footing that shunt-winding was known at its date. I do not think it necessary to deal with the conflict of testimony as to the sufficiency of Varley's specification for the guidance of a skilled workman. The Lord Ordinary was of opinion that the appellants had failed to prove that part of their case. But I agree with his Lordship, and with the learned Judges of the First Division, in holding that the sufficiency, or insufficiency, of the specification for that purpose does not afford a crucial test of prior publication. Every patentee, as a condition of his exclusive privilege, is bound to describe his invention in such detail as to enable a workman of ordinary skill to practise it; and the penalty of non-compliance with that condition is forfeiture of his privilege. His patent right may be invalid by reason of non-compliance; but it certainly does not follow that his invention has not been published. His specification may, notwithstanding that defect, be sufficient to convey to men of science and employers of labour information which will enable them, without any exercise of inventive ingenuity, to understand his invention, and to give a workman the specific directions which he failed to communicate. In that case, I cannot doubt that his invention is published as completely as if his description had been intelligible to a workman of ordinary skill.

Assuming as, in my opinion, I am bound to do, that Clark's invention was known in 1876, I have no hesitation in holding that Varley's specification sufficiently describes both the shunt and the series-shunt machine. The first sentence in the passage already quoted contains an accurate representation of shunt-winding. The electricity developed by the machine is to be "diverted," which is the word used in the appellants' specification to denote bifurcation, into two parts, one for magnetising, and the "remaining portion" for producing light. These expressions plainly refer to a single current of electricity generated by the machine, which is to be split into two currents, one for excitation of the magnets and one for work, an arrangement which, according to the evidence, embraces all the essential features of a shunt machine. The sentences which follow appear to me to describe the series-shunt with equal accuracy. They commence with the statement that there are several ways of "doing this," that is of obtaining a circuit of excitation and an electric lighting circuit from a single current, by dividing it into two portions. The method preferred is to make both circuits pass round the magnets, that of greater resistance being employed for excitation only, while that of lesser resistance excites the magnets, and also does the work of lighting. The series-shunt is evidently treated as a mere modification of the shunt system; and I think it might be reasonably regarded in that light by the patentee. The alteration in the mechanical arrangement of the apparatus is in itself trivial; and the possibility of thereby obtaining such a constant potential as would, at a future date, suffice for the purpose of incandescent lighting was not present to his mind. There might, as one of the witnesses suggests, still remain room for a patentable improvement upon the series-shunt as described by Varley, consisting in an adjustment which would ensure a high degree of constant potential. No such possibility is indicated either by Varley, or in Brush's patent of 1878.

In the argument addressed to your Lordships, counsel for the appellants laid much stress upon these words occurring in Varley's specification: "The insulated wire composing the helices is connected to the insulated wire surrounding the soft iron magnets of the machine, and is usually inserted in the circuit of greater resistance." They maintained that the necessary result of giving effect to that direction would be to deprive the apparatus contemplated by Varley of all the characteristics of series-shunt-winding. The point does not appear to have been pressed in the Courts below; at least, it was not put before the witnesses, and is not noticed by any of the Judges. In the absence of evidence to support the appellants' contention I have come to the conclusion that the adjustment thus indicated might affect the constancy of the volume of electricity conveyed by the electric light circuit, but that the apparatus would still be a series-shunt-winding machine. These reasons are sufficient to dispose of this appeal, and I desire to express no opinion upon the matter of prior public user. The argument of the appellants satisfied me that the question was one upon which I should prefer not to form any conclusion, without hearing counsel for the respondents. I therefore concur in the judgment which has been moved by the Lord Chancellor.

Lord HERSCHELL said that this is an appeal against interlocutors pronounced in an action of reduction brought by the respondents for the purpose of obtaining the revocation of certain letters patent then vested in the appellants. The letters patent in question bear date the 18th of May, 1878, and claim the invention of "improvements in apparatus for the generation and application of electricity for lighting, plating and other purposes." The original specification concluded with 16 claims, to only two of which I need now refer. The eighth claim is for what is termed in relation to dynamo-electric machinery, the "shunt" system, that is to say, a dynamo-electric machine, wherein a portion of the current produced is diverted for the purpose of maintaining a permanent magnetic field. The ninth claim is for what is now termed the shunt-series system or compound winding. In January, 1882, a disclaimer was filed, by which the eighth claim was abandoned, it having been discovered that the shunt system was not new at the date of the letters patent. The main question, and, indeed, in my opinion, the only question with which your Lordships need concern yourselves, is, whether the shunt-series system was a new invention at that date. It is alleged by the respondents that it was not only communicated to the public by the specification of the letters patent granted to Samuel Alfred Varley in December, 1876, but that a machine was, under his instructions, constructed on that system, and had been in actual use before the date of the patent now vested in the appellants. Varley's specification claimed a method of obtaining a high degree of "magnetic potential" in the bobbins of an electric machine, and the claim had no reference to the manner in which the electricity generated was to be employed, but there occurs in the course of the specification the following passage:—"Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light. There are several

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well known ways of doing this, but the method I prefer is to use the soft iron magnets with two insulated wires, one having a larger resistance than the other. The circuit of larger resistance is always closed, and the circuit of less resistance is used for the electric light. When the electric light is being produced, the greater portion of electricity passes through the circuit of less resistance, which I term the 'electric light circuit,' maintaining the magnetism of the magnets, and producing the light. When the electric light circuit is opened from any cause, the electricity passes through the circuit of greater resistance only and maintains the magnetism of the magnets." It is scarcely denied that to any electrician possessed of the knowledge of the present day, these words would convey the idea of the series-shunt system of winding. But it is said, and with truth, that this is not the test, and that the question is what idea they would convey to a person reading them prior to the date of the patent which is in contest in the present suit. The learned counsel for the appellants argued strenuously at the bar that in the light of the more limited information then available, such a reader would not be led to a knowledge of the device described in Brush's patent. They contended, moreover, that in other parts of Varley's specification statements are to be found, which, taken in connection with the passage relied on, would lead the reader away from the conception of this scheme of compound winding. It is necessary, therefore, to inquire what was the state of knowledge prior to 1878. The system of series-winding was well known. By this arrangement the current generated is led round the magnets, and from the magnets is conducted to the lamps, or to serve the other purposes for which it is to be employed, and then back to the machine so as to complete the circuit. This device was subject to the defect that the magnetism of the magnets might be diminished at the very time when it was desirable that the current generated should be maintained. In May, 1876, letters patent were sealed bearing date 11th of December previous, the specification of which, it is admitted, disclosed the shunt system of winding, by which one part of the current is diverted to maintain the magnetism of the soft iron magnets, whilst the remainder is used to produce the electric light, or serve any other purpose for which the current is required. It was urged on behalf of the appellants that there was no evidence that the invention just disclosed had become commonly known prior to 1878, or that it had ever been put in operation, and that Varley's specification ought, therefore, not to be construed on the assumption that those who read it would be acquainted with the shunt system of winding. I cannot accede to this view. It appears certain that at the date when he took out his patent Varley was acquainted with the shunt system, and, indeed, with the shunt-series system of winding, for this is conclusively established by the drawing made by him which was put in evidence. Of course I do not refer to this for the purpose of construing his specification, but only as bearing on the question whether the shunt system was known prior to 1878. The shunt system had been described in Clark's specification of 1875, and it is impossible to say that other electricians may not have been, like Varley, acquainted with it. Under these circumstances I cannot regard it otherwise than as part of the stock of public knowledge, which must be taken into account when approaching the construction of Varley's specification. Taking, then, the shunt system and the series system of winding as both known, what information ought the specification of Varley to be regarded as conveying? The words with which the important passage in Varley's specification commences appear to me to be apt to describe the shunt system. It is impossible not to be struck with the similarity of the language used to that which is to be found in the part of Brush's specification which was avowedly describing that system. I am not much struck with the suggestion that the words "the remaining portion is used to produce the electric light," indicate that the use was to be for that purpose alone, and that this portion of the current was to play no part in maintaining the magnetism of the magnets, and that the description is, therefore, inconsistent with the shunt-series system. It seems to me impossible so to understand the language employed when the import of the sentences which immediately follow is considered. Indeed, it is admitted by one of the defendants' witnesses, Prof. Silvanus Thompson, that the criticism resolves itself into this, that he finds in two sentences what he might have expected to find in one. But a passage such as that with which we are dealing, in which each sentence is obviously connected with those which precede and follow, must be construed as a whole, and such a criticism as that which has been applied to it appears to me wholly inadmissible. Then it is said that, although compound-winding is described, it would not be understood at that time to refer to compound-winding as now understood, but to the winding on the magnets of two wires the current of electricity in each of which was separately excited. But the fact that it is prescribed that one of the two wires is to have a larger resistance than the other, and the statement that when the electric light is being produced "the greater portion of electricity" passes through the circuit of less resistance, appear to me not to suggest the idea of separate excitation, but the contrary; and when the whole passage is read together this impression is strengthened. And it is admitted by defendants' witnesses that there is at least one passage in the specification inconsistent with the idea that separate excitation was contemplated. The argument that other parts of Varley's specification would lead the reader away from the conception of compound winding was mainly founded upon this passage:—"The insulated wire composing the helices is connected to the insulated wire surrounding the soft iron magnets of the machine, and is usually inserted in the circuit of greater resistance." It was argued that if this were done the circuit of greater resistance would not be always closed. This assertion is controverted. But whether it be correct or no, I do not think the words relied on would lead anyone reading the earlier part of the specification to the conclusion that the circuit of greater resistance was not intended to be always closed in face of the express statement that it was to be so. The other criticisms were, to my mind, of less weight, and I do not think that any part of the specification would divert a reader of the important passage on which the controversy has mainly turned from the idea of shunt-series winding. Sir W. Thomson, one of the defendants' witnesses, admits that it is quite probable that in 1876 a workman might have been led to series-shunt winding by Varley's descriptions. And Professor Silvanus Thompson says:—"If a workman of the present day were to read Varley's patent I think he would read it as describing a shunt-series machine, because he would read the knowledge of the present day into it, and that would alter the meaning he attached to the language." Now I admit the difficulty of divesting oneself of existing knowledge, and interpreting any description as it would have been interpreted when the stock of knowledge was more limited. But to anyone acquainted with the shunt and series systems, I think the same idea would be conveyed as is conveyed now. If to a person cognisant of these two systems the conception of their combination into the shunt-series system would have constituted a new departure, the case might have assumed a different complexion; but it is clear that Varley did not regard this combination as a new discovery. And I think it impossible to read Brush's specification without seeing that when once he had arrived at the shunt system, the application of it in conjunction with the series system appeared to follow as a corollary. His object was to secure a permanent magnetic field. He attained this object by means of the shunt system. His words are, "I attain my object by diverting from external work a portion of the current of the machine, and using it either alone or in connection with the rest of the current, for working the field magnets." He treats the shunt-series system, in truth, as a mere modification of the shunt system, of which he believed himself to be the inventor, though he has naturally a distinct claim to cover this modification. The learned counsel for the appellants laid great stress on the fact that, since Brush's specification, the shunt-series system has come largely into use, and deduced from it the argument that it could not previously have been known. But it must be remembered that the importance of this system has only become very marked since the incandescent lamp has come into use. In connection with this form of electric lighting it is no doubt of the highest importance to secure a constant potential. And this object is best attained by the shunt-series system; the defects of each of these systems when used separately tending to counteract one another when they are used in combination. But there is not a trace in Brush's specification of this idea of constant potential. What he was concerned to obtain was a permanent magnetic field. He expresses his preference for the combined systems, "especially for electro-plating machines." It is true that a certain number, not, I think, a very large number, of Brush's machines were introduced into this country for electro-plating purposes before the days of the incandescent lamp. It is, however, regarded as an open question whether pure shunt is not better for the purpose of electro-plating than series-shunt, owing to the possibility that the polarity of the magnets may be reversed. It would seem that whilst the latter system is more in vogue in America, the former is given the preference in this country. I am satisfied that neither Varley nor Brush had in his mind the importance of maintaining a constant potential. But for the reasons I have given I think that any electrician reading Varley's specification with a knowledge of the two systems of series and shunt would have found there a description which he would have had no difficulty in giving practical effect to, of the system of compound winding, known as series shunt. Having arrived at this conclusion it is unnecessary to determine the effect of the use of the machine constructed under Varley's instructions, though I think it would be a matter for serious consideration whether after that use the appellants' patent could be supported. I think the judgment of the Court below was right, and ought to be affirmed.

LORDS MACNAGHTEN and FIELD also concurred.

The appeal was accordingly dismissed with costs.

Dovey v. Pixley.

In the Queen's Bench Division on Saturday, before Mr. Justice A. L. Smith, the action of Dovey v. Pixley was tried. It was an action brought by the owner of house property at the Albert Embankment, Princes-street, Lambeth, against the liquidator of the Electrical Engineering Corporation (Limited) to recover between £200 and £300 in respect of damage alleged to have been done to premises the Corporation held under lease for the purposes of their business. The defendant denied personal liability. The plaintiff leased the premises to the Corporation in October, 1882. In March, 1891, the debenture holders sued the Corporation to get their rights ascertained as to what charge they had upon the Company's property. Mr. Justice North appointed the defendant receiver and manager in the action, and in April the Corporation passed a resolution for voluntary winding up under the supervision of the Court, the defendant being appointed voluntary liquidator. Mr. Justice Kekewich subsequently ordered a sale on the premises, which took place in July, and it was in connection with the sale and the removal of machinery that the damage was said to have been done.

Mr. COHEN submitted, on behalf of the defendant, that property did not vest in a liquidator, and that unless the plaintiff could prove that the defendant, as manager, did something he had not been directed by the Court to do there was no cause of action.

In the result,

Mr. JUSTICE SMITH said that no doubt the plaintiff had suffered, and if the plaintiff had got the right paymaster in Court he should have awarded him damages, but he had not. If the Corporation had been worth anything he had still his remedy and could prove for his claim; but having got an insolvent tenant he could not go against a man who never was tenant at all. He could not do so on the ground of covenant, nor on the ground of breach of duty or of tort. The defendant's answer was the order of the Court. His (the learned Judge's) opinion was that what the

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defendant did he did as receiver and manager, and not as voluntary liquidator; but it did not make much difference in which capacity he acted. It was said the defendant had been guilty of excess in allowing the premises to be torn about in a way he ought not to have done. The evidence was conclusive that the premises had been damaged, and Mr. Dovey had suffered; but he had sued the wrong defendant, and could not put his hand in Mr. Pixley's pocket.

Judgment for the defendant, with costs.

Re City of London Electric Lighting Company.

A sitting of the Consistory Court of London was held on Wednesday in St. Paul's Cathedral, before Dr. Tristram, Q.C., Chancellor of the Diocese of London, to consider petitions by the rector and churchwardens of the parishes of St. Bene't Sherehog and St. Nicholas Acons for faculties authorising them to grant small portions of the churchyards to the City of London Electric Lighting Company for the purpose of giving access to vaults to be constructed by the Company under the public footway in Pancras-lane and Nicholas-lane, adjoining the churchyards.

The CHANCELLOR OF LONDON, in giving judgment, said:—There is no precedent for the granting of a faculty under the circumstances mentioned in the two cases now before the Court. The present applications are made by the rectors of the two parishes, with the sanction of the parish vestries, but at the instance of the City of London Electric Lighting Company, for leave to construct a flight of steps, with an entrance thereto, underneath the edge of each of the churchyards, with the exclusive user of such steps, in order to give the Company access to chambers which it proposes to construct underneath the narrow street abutting on each churchyard, for the storage of an apparatus for converting electricity. If the Court has jurisdiction to grant a faculty to give the user of a way across a churchyard, it must equally have jurisdiction to grant the user of a way underneath a portion of a churchyard. The Court being of opinion that it is within its discretionary jurisdiction to grant a faculty for erecting the flight of steps underneath the churchyard, with an entrance thereto, for the object named, it remains for it to consider whether from the facts proved it ought to exercise such discretion in the present cases. I have had the advantage of inspecting these churchyards, accompanied by Major-General Webber, the chief engineer of the Company; and it occurred to me during the inspection, as it is proved by evidence, that unless the faculties are granted, the Company would be unable to introduce electric lights into the offices of this part of the City unless it were to construct entrances in the narrow streets, which Major-General Webber says in his evidence would be an intolerable inconvenience to the public, or unless it were by purchase to procure a right of entry to the chambers from one of the opposite houses, and this it might be unable to do without a private Act of Parliament. It is clearly, therefore, for the convenience of the parishioners that the faculties should be granted. With regard to the payment of £5 a year proposed to be made by the Company in respect of St. Bene't Sherehog, the rector is prepared to assent to the payment being expended in keeping the churchyard in order. With regard to the voluntary payment proposed to be made to the churchwardens of St. Nicholas Acons, as the rector consents to the sum of £20 a year being paid as a contribution by the Company to a church fund for keeping up the church and churchyard, the Court will by the faculty sanction such payment. The Court decrees the faculties, subject to the terms mentioned.

Woodhouse and Rawson United (Limited) v. Alexander, Wright & Co.

In the City of London Court on Friday last, before Mr. Commissioner Kerr, Messrs. Woodhouse and Rawson United (Limited) sought to recover a debt due from the defendants, Messrs. Alexander, Wright and Co., Millbank-street, Westminster. The claim was not in dispute, but the defendants raised a counter claim for goods supplied to the plaintiff Company.

Mr. W. HICKS, for the plaintiffs, said the counter claim should have been brought against the Woodhouse and Rawson Electric Supply Company of Great Britain, and not against the plaintiffs, who were a distinct Company altogether. The "United" Company was not connected in any way with the Electric Supply Company, which was in liquidation.

The DEFENDANT said there were a great many Woodhouse and Rawson Companies, and he believed they were all one and the same.

Mr. COMMISSIONER KERR said no doubt the plaintiff Company was practically the same as the other one mentioned.

Mr. HICKS repeated his assurance that the Companies were quite distinct.

Mr. COMMISSIONER KERR said he should find for the defendant beyond the money paid into court, disallowing any costs.

BOOKS, &c., RECEIVED.

"Die Accumulatoren für Elektricitat." By Edmund Hoppe. (Berlin: Julius Springer. Price 7 marks.)

"Transactions of the American Institute of Electrical Engineers." Vol. VIII. (New York: The Institute.)

"Problèmes d'Electricité." By Dr. Filippo Cintolesi, Translated into French by Felix Leconte. (Gand. Libraire Générale de Ad. Hoste.)

"Annual Catalogue of the Massachusetts Institute of Technology." (Boston: Alfred Mudge and Son.)

CORRESPONDENCE.

THE GENERAL ELECTRIC POWER AND TRACTION COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been drawn to a paragraph respecting this Company in your last issue. The statement that the Kentish Town Works have been closed is not quite accurate, and is certainly premature. The arrangement as it stands at present is merely a reduction of unnecessary working expenses, and will, no doubt, enable my Company to occupy a stronger position than ever.

The whole management of the Company has been changed, and I may take this opportunity of saying that the other departments of the Company's operations, especially the electric launch business, are in an exceedingly prosperous condition.

Trusting you will kindly insert this correction, as the paragraph in your last issue was somewhat misleading, I am, &c.,

THE GENERAL ELECTRIC POWER AND TRACTION COMPANY (LIMITED),

April 7, 1892. T. SMITH, Secretary.

[The note in question was not inserted without due inquiry and confirmation, but we regret that we omitted to obtain fuller corroboration from the Secretary of the Company.—ED. *E.*]

THE ROUNDHAY ELECTRIC TRAMWAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of April 1st you seem to have misunderstood my statements at the discussion upon Mr. Reckenzaun's Paper before the Institution of Electrical Engineers, and in your "Notes" upon same you are open to corrections, viz.:—

The difficulty in obtaining men to look after and run the motors is very real, and it is only to be expected, when it is remembered how small is the field in this country for men to obtain even a very rudimentary knowledge of traction motors and their handling. We have had to train, *ab initio*, some twelve to eighteen men for drivers. The details, electrical and mechanical, of our system have given the most perfect satisfaction here, as they have heretofore in the States. My point at the discussion was that this being the first Thomson-Houston road in operation under English conditions, physical and atmospherical, necessitated the greatest care and attention in the observation of details of working, so as to enable us to perfect in every possible way the adaptation of such details to the new conditions, which in many points differ materially from our American work. To do this involves the employment of a larger and more expensive staff than would be needed for pure commercial working. Hence a large general expense account.

The cost I quoted of 6.63d. per car mile includes *everything* in connection with the operating and general expense of the road; and this sum will be materially reduced when we have some weeks of fair weather to average the very hard winter which has held throughout Yorkshire. If I am not mistaken the figures you quote for accumulator cost of traction are *paper figures* and were largely exceeded in practice. These four and a-half pennies did not include anything more than cost and maintenance of power and drivers; when my costs are made to only include these items the comparison puts the overhead system in this country in the same position *re* costs that it holds in other countries, *i.e.*, far in front of all competitors.

This figure, speaking without the book, is on our road under 3·80d. for cost of power, maintenance, and drivers; and please to remember this is from actual working, and is not an empirical cost for the purpose of business.

I trust that my few explanations contained herein will serve to show more clearly the actual facts about Leeds; and apologising for occupying so much of your valuable space, I beg to remain, yours, &c., W. S. GRAFF BAKER.

Leeds, April 4, 1892.

[The remarks in our Notes were chiefly directed to the necessity, to which Mr. Baker merely alludes, for the adaptation of the details to the new conditions. These, he says, differ materially in many points from American work. His "few explanations" do not touch on these differences and new conditions. We should be glad to hear, at least, what they are.—ED. *E.*]

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OIL AS AN INSULATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the authorised abstract which appeared in your journal of the discussion on Prof. Hughes's Paper, I notice that I am credited with saying that the resistance of certain oils varies 20 per cent. between 16° and 24° C. This should read "between 16° and 18° C."

I should be much obliged by your inserting this correction in the next issue of your journal.—Yours, &c.,

H. CUTHBERT HALL.

52, Queen Victoria-street, London, E.C.,
April 1, 1892.

LORD ARMSTRONG'S MAINS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the Note contained in your issue for the 25th inst., with regard to the outdoor mains that Messrs. Drake and Gorham are putting into the installation that they are erecting for the Duke of Montrose, it appears to me only fair that it should be mentioned that this system of mains, which, as it seems, is being copied from that that has been in successful operation at Lord Armstrong's for some years past, was not originally introduced by Messrs. Drake and Gorham, but was designed in its entirety by Lord Armstrong and myself, and was erected by Lord Armstrong's own estate workmen.

The system is of some interest, as it forms, probably, the first practical example of the arrangement of bare conductors laid on insulating blocks, since so widely employed for low-tension distribution from central stations.—Yours, &c.,

A. A. C. SWINTON.

66, Victoria-street, London, S.W.,
March 28, 1892.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.

The tenth annual edition of the above well-known annual is now ready, price 7s. 6d.; post free, in the United Kingdom, 8s 3d.; abroad (with the exception of a few countries), post free, 8s. 10d.

The edition consists of between 900 and 1,000 pages, and special care has been taken to make the Directorial division of the book, which has been considerably extended, thoroughly accurate and reliable. In this respect no possible comparison can be made with any similar publication.

To the Handbook division has been added several features which will be found of service to the Electrical and Allied Trades. The Digest of the Law of Electric Lighting has been thoroughly revised and brought up to date, and the most recent Board of Trade Regulations are also included. The various tables and tabulated statements have been remodelled and amplified; and a new feature is the tabulation of valuable information respecting Electrical Limited Liability Concerns.

An important feature is the space devoted to the officials of Foreign and Colonial Governments who have the superintendence of contracts and the giving of orders for electrical plant and apparatus; and as this has been kindly supplied by the various Government departments, it can be relied upon, as can also the particulars given respecting the Home Government departments.

The profession will find "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK a trustworthy work of reference, and purchasers of plant and apparatus may confidently turn to its pages for the names of all the principal firms supplying their requirements. Nearly every firm of any standing in the Electrical and Allied Trades is represented in its advertisement pages.

A digest of the contents of the book will be sent on application.

VACANT APPOINTMENT.—An engineer is wanted, accustomed to the erection of land lines. The appointment is for Argentina and Chili. Further particulars are given in our advertising columns.

THE LANE FOX PATENTS.—It is announced, by Messrs. Vandercom and Co., solicitors, that application will be made to Her Majesty in Council praying that the letters patent of Mr. Lane Fox for improvements "in distributing and regulating the electric current or obtaining light by electricity and in the means or apparatus employed therein," may be extended for a further term, and that on May 9th next (or thereabouts) application will be made to the Judicial Committee of the Privy Council for the hearing of the said petition.

REMOVAL NOTICES.—Messrs. Wheatley Kirk, Price, and Goulty notify us that they have removed from 52, Queen Victoria-street to 49, Queen Victoria-street (Albert-buildings), immediately opposite the Mansion House Railway Station, to which new address all future communications are to be sent.

——— Mr. R. G. Ivey has removed from Chatham-place, Hackney, to larger premises at 7, Portpool-lane, Gray's Inn-road, W.C.

MESSRS. POOLE AND WHITE (LIMITED).—This firm have just opened a branch office at 27, Arcade-chambers, St. Mary's Gate, Manchester, under the management of Mr. T. A. Nunwick, representative of the firm for the North of England.

INCANDESCENT LAMP PRICES.—The Edison and Swan Company notify special discounts on incandescent lamps to the trade, as dating from April 1st. These discounts are subject to certain conditions, particulars of which will be found in our advertisement pages.

MESSRS. FRITSCHE AND PISCHON.—We have received a notification that Herr C. H. Pischon has ceased to be a member of this firm.

CROMPTON-HOWELL BATTERIES.—We are in receipt of the newly issued illustrated catalogue and list of prices of the Crompton-Howell Electrical Storage Company (Limited). Several types of battery are illustrated in the catalogue, and a list of the installations is given in which the batteries are used.

NEW EDITION.—Messrs. Whittaker will shortly issue a fifth edition of Mr. Bottone's work on "Electrical Instrument Making," revised, and with additional chapters.

THE ENGINEERING EXCHANGE FOR LONDON.—A meeting to inaugurate the above was held on Wednesday last in the Cannon-street Hotel, Mr. Reginald Bolton occupying the chair. Resolutions were passed giving effect to the draft scheme, which we published last week; and a provisional committee, consisting of Messrs. R. Bolton, Tyler, Potter, Frederick Rawson, Hargreaves, Henriques, and Devicien was named, to take steps to form and open the Exchange immediately. We understand that this committee will for the present co-operate with and share the premises of the Jerusalem Shipping Exchange.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by MR. J. C. CHAPMAN, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS.

March 8, 1892.

4,523. THE RIES ELECTRIC SPECIALITY COMPANY. London. Regulating sockets or holders for incandescent electric lamps and other translating devices.

4,543. G. WILSON. Aberdare. Electrical measuring instruments.

4,576. J. V. SHERRIN. London. Improvements in secondary batteries.

4,578. A. C. CAREY. London. Improvements in and relating to applying carbon filaments to electric lamps.

4,579. S. A. ROSENTHAL and J. V. SHERRIN. London. Improvements in galvanic batteries and battery liquids.

4,586. C. T. THOMPSON and R. H. SANDERS. London. Improvements in magnetic separators for ore and similar material.

4,610. G. F. PINKHAM. London. Improvements in electric gas-lighting burners.

4,617. F. A. FELDKAMP, J. SCHOENHAAR, and E. E. LEHR. London. Improvements in electrical attachments for pianos.

March 9, 1892.

4,691. E. SCHWEIZER. London. Improvements in secondary electric clocks.

4,709. R. F. YORKE. London. An improved method of and means for electric wiring.

March 10, 1892.

4,758. W. BOGGETT. London. Improvements in the methods and means of obtaining electricity.

4,764. H. H. LAKE. London. Improvements in insulators for electric wires. (C. N. Hammond, United States.)

4,768. S. W. MAQUAY. London. Improvements in electric batteries.

4,773. G. F. REDFERN. London. Improvements in the manufacture of electrical conductors. (S. Bergmann, Germany.)

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4,779. J. J. Rathbone and J. Houghton. London. An improvement connected with electric arc lamps.

March 11, 1892.

4,816. W. Fairweather. Glasgow. Improvements in electrical cables. (E. F. Phillips, United States.)

4,820. L. Mercky. London. Improvements in primary batteries.

4,841. W. L. Spence. Manchester. Improvements in the methods of driving electric railway trains.

March 12, 1892.

4,883. W. F. Taylor. Croydon. Improvements in methods of alternating current distribution.

4,930. P. Manchin. London. Improvements in and relating to fusible cut-outs.

March 14, 1892.

4,949. A. F. Willman. London. The generation of electricity for electric lighting and other purposes.

4,955. C. S. Bedford. Leeds. Improvements in the manufacture of insulating materials.

4,961. A. Muirhead. London. Improvements in slide resistances for electrical purposes.

4,988. C. E. Thomson. London. Improvements in electric-circuit closers.

4,992. H. Edmunds. London. Improvements in insulated electric conductors and means to be employed in their production.

5,002. G. Wilkinson. London. Improvements in electrical conductors and means for laying the same.

March 15, 1892.

5,052. G. Davis. London. Electrically driven whipper for eggs, creams, sauces, and the like.

5,085. W. P. Hall. London. Improvements in electric block signalling apparatus.

5,096. E. J. Silkman. London. Printing telegraphs.

March 16, 1892.

5,130. G. G. Crosby and Don C. A. Thatcher. London. Improvements in magnetic ore separators.

5,141. C. S. Snell and Woodhouse and Rawson United (Limited). London. Multiple fuses and switch for use in electric circuits.

5,161. J. S. Vost and F. R. Fisher. Halifax. An improved telephone cabinet.

5,186. L. Lenczewski. London. Improvements in electric arc lamps.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1890.

20,992. Jones. Electric bells.

1891.

2,040. Müller. Secondary batteries.

2,471. Bush and Doubleday. Electrical batteries.

4,064. Hookham. Electricity meters.

4,306. Boggett. Dynamo-electric generators.

4,740. Attree. Electric signalling for railways.

5,167. Elmore, F. E. and A. S. Making tubes by electrolysis.

5,342. Callendar. Electrical thermometers.

5,947. Chapman. Incandescent electric lamps.

6,517. Dorman and Smith. Electric light switches.

6,660. De Ferranti. Distributing electrical energy.

6,978. Boult. (Stone.) Dynamo-electric machines.

7,075. Royce. Electric lamp holders, &c.

7,283. Bennett. Telegraphy and telephony.

7,331. Abel (Société Générale des Téléphones). Telephonic apparatus.

7,430. Heaviside and Others. Driving dynamo-electric machines.

7,433. Solomons. Testing electric lightning conductors, &c.

7,518. Bullock and Brown. Telegraph instrument.

7,531. Cuthbert. Tools for electric linemen.

7,697. Elieson. Storage batteries.

7,728. Lea. Electric lamp-posts.

8,048. Kennedy. Dynamo-electric generators.

8,151. Siemens Bros. and Co. (Limited) (Siemens and Halske.) Distributing alternating currents.

8,227. Thompson. (Tudor.) Electric accumulators.

8,845. Haddan. (Cabanyes.) Galvanic batterie .

10,451. Haywood and Driver. Electric light, &c., posts.

16,958. Mavor and Others. Electric lighting, &c. conductors.

19,968. Burt. Electric motors, &c.

1892.

1,391. London Metallurgical Co. (Limited) and Cowper Coles. Coating articles by electro-deposition.

1,396. Eichler. Electric circuit-breaker.

1,484. Entz and Phillips. Secondary batteries.

1,580. Mathews. Electric low-water alarm.

2,016. Price. Conduits for electrical cables, &c.

2,026. Lake. (Grissinger and another). Electrical telephones.

2,290. Ries. Electric riveting.

COMPANIES' MEETINGS.

House to House Electric Light Supply Company (Limited).

The fourth ordinary general meeting of this Company was held at the Company's Central Station, Richmond-road, Kensington, on Tuesday last, under the presidency of Mr. Henry Ramié Beeton.

The SECRETARY (Mr. H. St. John Winkworth) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen—The report and accounts set out, of course, most of the facts connected with the progress of the Company for the year 1891, and I think that the shareholders will probably agree with me that the result is comparatively satisfactory. It will be seen that the capital expenditure for the twelve months has amounted to £8,996, and that the increased revenue is upwards of £3,300, which has been earned at a percentage of working expenses of 41 per cent., thereby reducing the percentage of expenses from 92 per cent. in 1890 to 79 per cent. in 1891. The profits would have been much larger if the rate of progress during the year had been equal to that of the preceding year. Unfortunately, it has not been quite maintained. On December 31, 1889, there were connected with the Company's mains 4,520 35-watt lamps, and on December 31, 1890, there were connected 13,665 of the same lamps, showing an increase during the year of 9,145. On December 31, 1891, there were connected with their mains 19,388 35-watt lamps, showing an increase during the year of 5,723. Since the close of the year 871 had been added, raising the total connected on March 31st to 20,259, and there is every indication from the orders in hand and the general development of the district that we shall have a satisfactory increase during the year. The Company has, of course, benefited by the administrative economies which I referred to at the last general meeting as being on the point of being introduced. In addition to that it has been benefited by improvements in the works, which have been effected as the result of greater experience and more perfect organisation. The condition of things which these facts disclose will, I think, justify the assumption that any future increments of capital are likely to be employed at a high rate of productivity, and that after the claims of such capital have been satisfied there wi l be left a surplus which will go to the ordinary shareholders. At our last general meeting I was able to announce that the negotiations which had been for some time on foot for the benefit of our construction asset were on the point of being concluded; and although their consummation was delayed longer than I anticipated at the time, I am pleased to say that we have at length participated in a contract with the Leeds and London Electrical Engineering Company, whereby our Company, although it will not enjoy a large share of the profits of that undertaking, will not, on the other hand, be called upon to provide any funds, or take any further risk. Moreover, we are guaranteed £525 a year for two years, and if the business is as successful as it promises to be we may get more than this for many years. With these few remarks I beg to move that the report and accounts be adopted.

The MANAGING DIRECTOR (Mr. Robert Hammond) in seconding the motion, thought that the shareholders would be interested to know that the rate of increase of their business during the year would have been much larger if the Company's plant had permitted its engineers to take on more orders. They had been somewhat deficient in point of plant, and the active canvassing for business which went on in the previous year had not been continued in 1891. They might therefore fairly say that in the coming year, when further plant would be added to the station, they would have a considerable number of lights added to their circuit. Since the accounts were closed more preference capital had been issued, and freely taken up, amounting to £12,290, which would enable the Directors to spend more money in the works, thereby increasing their output. He thought that the Chairman was justified in alluding to the favourable prospects of the Company. Their business had been gradually increasing, and the Directors were not taking too sanguine a view in forecasting the future. They had reached that point of the Company's history when they were getting on a dividend-paying basis, a circumstance on which he heartily congratulated the shareholders. It might be known to them that the Leeds and London Electrical Engineering Company was formed for the purpose of dealing efficiently with the so-called construction asset of the House to House Electric Light Supply Company, it being felt that the latter should devote its energies to the supply of electricity from house to house, leaving to another company the manufacture of machinery and the erection of stations. An agreement on these lines had been made with the Leeds and London Company, of which he was a Director, and he was pleased to say that a notice appeared in a morning paper of the preceding day to the effect that at the meeting of the Burton-on-Trent Corporation, on Wednesday, the electric lighting committee were to recommend that the contract for the central station at Burton-on-Trent should be given to the Leeds and London Company, on whose profits they had a large charge, so that the £525 alluded to by the Chairman might this year be £1,050, if not more. He was glad to inform the shareholders that the Yorkshire House to House Electricity Supply Company, which brought grist to the mill of the Leeds and London Company, had had a certain amount of capital subscribed, which would result in a profit to that Company, with which they were practically affiliated. He concluded by saying that the light supplied by the Company met with general approval, and no company more satisfactorily fulfilled its obligations to its customers than did theirs.

In reply to Mr. ARTHUR KIMBER,

Mr. HAMMOND added that the accounts were made up in the form prescribed by the Board of Trade.

The motion was carried unanimously.

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The CHAIRMAN proposed, and Mr. DAVIES seconded, the declaration of a dividend at the rate of 7 per cent. on the preference shares.

The motion having been agreed to,

Mr. HAMMOND moved, and Mr. WM. PAGE seconded, the re-election of Mr. Beeton to his seat at the Board.

The motion was agreed to *nem. con.*

The CHAIRMAN proposed, and Mr. W. F. LEESE seconded, the re-election of Mr. Hammond to his seat at the Board, which was also carried unanimously.

The CHAIRMAN next proposed the election of Mr. Leese as a Director.

Mr. JAMES WHITEHEAD seconded the motion, which was carried.

The CHAIRMAN explained that Mr. Joaquin de Galindez had been obliged to go abroad, and did not, therefore, offer himself for re-election. The other election to the Board was that of Mr. Reginald Davies, whose services had been and would be very beneficial to the Company, and he had much pleasure in proposing it.

Mr. HAMMOND seconded the motion, which was carried unanimously.

Mr. KIMBER proposed, and Mr. WHITEHEAD seconded, the re-appointment of the auditors, Messrs. Theobald Bros. and Miall.

The motion having been agreed to, Mr. HAMMOND proposed and a SHAREHOLDER seconded a vote of thanks to the Chairman, who briefly returned thanks, and the proceedings terminated.

The Telephone Company of Egypt (Limited).

The ninth ordinary annual general meeting of this Company was held on Tuesday at the offices of the Company, 14, Austin Friars, under the presidency of General Alexander Fraser, C.B., R.E.

The SECRETARY (Mr. Alexander B. Chalmers) read the notice calling the meeting; and the Directors' report and statement of accounts were taken as read.

The CHAIRMAN said he had very little to say beyond what was contained in the report circulated among the shareholders. The business generally had continued in an even course during the past year, and they were glad to be able to propose the usual dividend of 6 per cent. on the Preferred shares. The business, he said, was one he did not think would further improve by leaps and bounds: but they might hope that under the good management of their staff in Egypt there would always be a small annual increase in the number of their subscribers taken as a whole. It was true that that increase was sometimes discounted by a demand for lower rates, a demand, however, they had been forced to resist when they thought that the rates were as low as an efficient service would permit. It was an efficient service, and they were, he thought, justified in considering it so in the absence of complaint. Their manager in Egypt was a very good officer of the Company, and with the careful supervision of his accounts by the Secretary and his staff, the Board was enabled to keep the cost of the service at the lowest possible point consistent with efficiency. He concluded by formally proposing—

"*That the report and accounts for the year ended 31st December, 1891, be and are hereby approved and adopted, and that a dividend be paid of 6 per cent. on the Preference shares, free of Income Tax.*"

Mr. THOS. LLOYD seconded the motion, which was carried unanimously.

Mr. GREWING next moved—

"*That General Alexander Fraser, C.B., R.E., be and he is hereby re-elected a Director of the Company.*"

Mr. LLOYD seconded the motion, which was also carried unanimously.

On the motion of Mr. ADDISON seconded by Mr. HENTSCH, the auditors of the Company, Messrs. Price, Waterhouse, and Co., were re-appointed. Mr. ADDISON also moved a vote of thanks to Mr. Evans and the staff in Egypt, which was carried unanimously.

A further vote of thanks to the Chairman for presiding terminated the proceedings.

The Electric Construction Corporation (Limited).

An extraordinary general meeting of the shareholders of this Company was held at Worcester House, Walbrook, on Thursday, the 7th day of April, for the purpose of considering, and, if thought fit, confirming as special resolutions, the resolutions which were duly passed at a general meeting, held at the same place, on the 22nd day of March, 1892; Mr. J. Spencer Balfour, M.P., presided.

Mr. W. SAMSON (the Secretary) having read the notice calling the meeting, and the resolution to be confirmed,

The CHAIRMAN said: Gentlemen, you have heard the resolution read, and the subject matter of the resolution has been considered by no less than three general meetings of this Corporation, and at each of these meetings the resolution has been unanimously approved. I assume you will not, therefore, wish me to occupy your time now in moving, as I do—

"*That the resolution which was duly passed at the meeting held on the 22nd of March, 1892, be, and the same is hereby, confirmed as a special resolution, viz.:—'1. That one-half of the said new shares, being those numbered 62,501 to 75,000 inclusive, be allotted and issued by the Directors to such persons and at such times as the Directors shall think proper, and that the said shares shall be Preference shares, and shall entitle the holders thereof to a cumulative dividend at the rate of 7 per cent. per annum upon the amount credited as paid up thereon, in priority to any dividend on the Ordinary and Founders' shares of the Company. 2. That the said Preference shares shall also entitle the holders thereof, upon a return of capital of the Company, to be repaid the amounts credited as paid thereon, before any payment in respect of capital is made on the Ordinary and Founders' shares of the Company.'*"

I beg to move that resolution.

Mr. J. IRVING COURTENAY (Deputy-Chairman) seconded the resolution.

No questions were asked, and the resolution was put and carried unanimously.

A vote of thanks to the Chairman closed the meeting.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

CHELMSFORD ELECTRIC LIGHTING COMPANY (LIMITED).—This Company was registered on March 30th, with a capital of £10,000, divided into 7,500 preferred and 2,500 ordinary shares of £1 each, by E. H. F. Reeves, Little Heath, Potters Bar. The objects are to enter into and carry into effect, with such modifications (if any) as may be agreed upon, the draft contract already prepared in the name of this Company, and made with Messrs. Crompton and Co. (Limited), for the purchase and transfer to this Company of the Board of Trade licence to supply electricity in the borough of Chelmsford, Essex, and of the electrical installation and agreements in connection therewith; to carry on the business of electricians, mechanical engineers, and manufacturers, and workers of and dealers in electricity, motive power and light; to carry on the business of manufacturers of and dealers in machines, lamps, lanterns, safety lamps, and other appliances for supplying light and power by means of electricity; and to acquire the right to use and put up telephones, telegraphs, phonographs, &c. The signatories to the Memorandum and Articles of Association are:—

	Shares.
John F. Albright, Arc Works, Chelmsford, engineer	1
Carleton F. Tufnell, Lloyd's, E.C., underwriter	1
Hugh G. W. Drummond, 7, Ovington-square, S.W.	1
James Luckin, Chelmsford, chartered accountant	1
James S. Brown, Chelmsford, merchant	1
John P. Bond, Chelmsford, draper	1
Garrard Baker, Chelmsford	1

The number of Directors is not to be less than three nor more than five, the first to be nominated by the subscribers to the Memorandum of Association. For the rest, the regulations of Table A mainly apply.

HICKS, HARGREAVES, AND CO. (LIMITED).—This Company was registered on March 29, 1892, with a capital of £240,000, in £10 shares, by Rowcliffes, Rawle, and Co., 1, Bedford-row, W.C. The objects are to acquire the goodwill of the business carried on by John Henry Hargreaves, Francis Hargreaves, and Percy Hargreaves, under the style or firm of "Hicks, Hargreaves, and Co.," at the Soho Iron Works and the Phœnix Boiler Works, Bolton, and to carry on the businesses of iron-founders, engineers, boiler makers, and millwrights.

MADRAS ELECTRIC TRAMWAYS COMPANY (LIMITED).—This Company was registered on April 2, 1892, with a capital of £100,000, in 100,000 ordinary shares of £1 each, by Paul E. Vanderpump and Eve, 5, Philpot-lane, London, E.C. The objects are to acquire a concession which was granted by the municipal authorities of Madras for the construction of tramways in Madras, and with that object to adopt and carry into effect an agreement dated March 16, 1892, between William Digby and Sidney A. Chalk of the one part, and Frederick W. Fowler, on behalf of this Company, of the other part; to carry out the construction of the said tramways, and when so constructed to work the same either with electricity conveyed through overhead or underground wires, animal power, steam, or other mechanical power, and to carry on the business of tramway proprietors, electrical engineers and manufacturers, electric light engineers, and businesses analogous thereto. The subscribers are:—

	Shares.
W. Digby, 1, Trafalgar-buildings, Northumberland-avenue, S.W., merchant	1
Alfred J. Lustay, 70, Gracechurch-street, E.C., colliery proprietor	1
S. A. Chalk, 1, Trafalgar-buildings, Northumberland-avenue, S.W., merchant	1
A. E. Asser, Suffolk Lodge, Teddington	1
M. M. Bhownaggree, Tessville, Priory-road, Bedford Park, barrister-at-law	1
W. A. Gibson, 4, Queen Victoria-street, E.C.	1
Henry E. Eve, 5, Philpot-lane, London, E.C., solicitor	1

The number of the Directors is not to be less than three nor more than six, the first Chairman being W. Digby and S. A. Chalk, Managing Director

R. BARRETT AND SON (LIMITED).—This Company was registered on March 30, 1892, with a capital of £100,000, divided into 25,000 preference and 75,000 ordinary shares of £1 each, by Burn and Berridge, 11, Old Broad-street, E.C. The objects are to acquire the goodwill of the business of R. Barrett and Son, engineers, iron and brass founders, and manufacturers of automatic machines, and to carry on the business of iron and brass founders, engineers, manufacturers of automatic and other machinery, tool makers, metal workers, boiler makers, machinists, iron and steel converters, smiths, metallurgists, and electrical engineers. Registered office: King's Head-court, Beech-street, Barbican, London, E.C.

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BICESTER ELECTRICITY SUPPLY COMPANY (LIMITED).—The statutory return of the above-named Company, made up to March 16, 1892, was filed on March 30, 1892. The Company was registered on November 2, 1891, with a capital of £5,000, in £5 shares; and, at the time of making up, 131 shares were taken up, 10s. called on each, and all calls (£65. 10s.) paid. Of the shareholders, 25 out of the 28 reside or trade in Bicester. No agreements for the purchase of any contracts, plant, businesses, &c., have been filed.

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—The following notice was filed on April 1, 1892:—At an extraordinary general meeting of the Electric Construction Corporation (Limited) duly convened and held at Worcester House, Walbrook, in the City of London, on Thursday, March 3, 1892, the following resolution was duly passed; and at a subsequent extraordinary general meeting of the Company, also duly convened and held at the same place on Thursday, March 22, 1892, the following resolution was duly confirmed as a special resolution:—"That the capital of the Company be increased to £750,000 by the creation of 25,000 new shares of £10 each, numbered 50,001 to 75,000 inclusive."

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above named Company, made up to March 24, 1892, was filed on March 30th following. The Company was registered on March 29, 1888, with a capital of £250,000, in £5 shares. The capital is now £350,000, divided into 50,000 ordinary, 10,000 first preference, and 10,000 second preference shares of £5 each. At the time of making up, 15,000 ordinary and 10,000 first preference shares have been taken up, of which 5,000 ordinary shares have been issued as fully paid. Upon the remaining 10,000 ordinary and 10,000 preference shares, the full amounts have been called, and all calls (£100,000) paid. Among shareholders holding more than 500 shares are Sir Richard E. Webster, of 2, Pump-court, Temple, E.C. (1,600).

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 8, 1892, was filed on the following day. The Company was registered on January 8, 1889, with a capital of £50,000, in £5 shares, with objects as fully indicated by the title. At the time of making up 5,106 out of the 10,000 shares were taken up, of which 18 had been issued as fully paid. Upon 4,066 of the remainder £4 per share had been called, and upon the remaining 1,022 shares £3 per share had been called, resulting in the payment of £20,602 (including £1,572 paid in anticipation of calls), and leaving £300 in arrears.

PONTYPRIDD ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 16, 1891, was filed on March 4, 1892. The Company was registered on April 30, 1889, with a capital of £10,000 in £5 shares. At the time of making up seven shares were taken up, upon which no calls had been made, the original signatories being the only shareholders. No agreements of any kind have been filed.

SOUTH-WESTERN DISTRICT AND THAMES VALLEY ELECTRICITY SUPPLY COMPANY (LIMITED).—The annual return of the above-named Company, made up to December 31, 1891, was filed on March 14, 1892. The Company was registered on June 28, 1889, with a capital of £100,000, in £10 shares. At the time of making up seven shares had been taken up, upon which, however, no calls had been made. A note in the "Remarks" column of the return states that "nothing has yet been done in this Company beyond registering the name and paying the registration fees; but it is intended to begin work next autumn. The stagnation has been due to the enforced absence of myself abroad since November, 1890, until quite lately. (Signed) Daniel de Castro (Chairman)."

THORNEBURRY MINERS' SAFETY LAMP COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 8, 1892, was filed on March 14th following. The Company was registered on May 5, 1890, with a capital of £50,000, in £1 shares, to carry on business as manufacturers of safety lamps, electrical and mechanical engineers, &c. At the time of making up, 30,057 shares had been taken up, of which 20,540 had been issued as fully paid. Upon the remaining 9,517 shares the full amount had been called, resulting in the payment of £8,976, and leaving £541 in arrears. The return for 1891, made up to December 31, 1891, was filed on March 16, 1892, when the same number of shares were taken up, and the same number issued as fully paid. The calls paid then amounted to £7,704. 5s., leaving £1,812. 15s. unpaid.

VAUGHAN-SHERRIN ELECTRICAL ENGINEERING COMPANY (LIMITED).—An agreement made March 9, 1892 (and filed on the 15th following), between S. A. Rosenthal, of 6, Christopher-street, Finsbury, E.C. (the vendor), of the one part, and the Company of the other part, states that whereas by an assignment dated March 25, 1891, between the same parties, the vendor assigned to the Company an invention consisting of a method of turning acid fluids and acid mixtures into a jelly or paste, and all improvements therein, in consideration of a sum of £250 in cash, and the allotment of 250 fully paid-up ordinary shares of £5 each. The present agreement determined that on March 17, 1892, the Company should allot to the vendor or his nominee 250 fully paid-up ordinary shares of £5 each, to be numbered 1,548 to 1,797 inclusive. The annual return of the Company, made up to February 14, 1892, was filed on March 21st following. The Company was registered on August 16, 1890, with a capital of £25,000, divided into 4,975 ordinary shares, and 25 Founders' shares of £5 each. At the time of making-up, 4,034 ordinary and 25 Founders' shares had been taken up, of which 2,487 ordinary and nine Founders' shares had £2. 10s. considered as paid on each. Upon the remaining 1,547 ordinary and the 16 Founders' shares £4 per share had been called, and the calls paid amount to £5,766, leaving £486 unpaid.

WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).—The annual return of this Corporation, made up to March 9, 1892, was filed on March 28, following. The Company was registered on June 30, 1888, with a capital of £100,000, divided into 19,900 ordinary and 100 founders' shares of £5 each. By special resolution passed on October 11, 1889, and confirmed on October 30, 1889, the capital of the Company was raised to £300,000, by the creation of 40,000 new shares of £5 each. At the time of making-up, all the shares had been taken up, the full amounts had been called, and all calls (£300,000) have been paid.

WREXHAM AND DISTRICT ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 15, 1892, was filed on the same day. The Company was registered on December 19, 1889, with a capital of £20,000, in £5 shares. At the time of making up, 115 shares had been taken up, upon which no calls had been made. Nearly all the shareholders are residents in the district. No agreements for the purchase of contracts, plant, businesses, &c., have as yet been filed.

YORKSHIRE HOUSE TO HOUSE ELECTRICITY COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 11, 1892, was filed on March 16, 1892. The Company was registered on June 26, 1889, with a capital of £100,000. At the time of making up, 100 founders' and 7 ordinary shares had been taken up, and upon the 7 ordinary shares no calls have been made. The original signatories are the only shareholders, with the exception of the House to House Electric Light Supply Company (Limited), who hold the 100 founders' shares. (From the above it will be seen that only a portion of this Company's capital had been issued at the time of making up the annual return. Last week, however, a prospectus was issued, inviting applications for £50,000, in 10,000 ordinary shares of £5 each, and 50 founders' shares of £5 each were offered at par to the first 50 subscribers of £500 each of ordinary shares. A noticeable feature in the prospectus is the number of contracts entered into, chiefly with the parent House to House Supply Company, and Messrs. Hammond and Co., whose figures form the basis of glowing anticipations of future profits. Clause 5 of the Prospectus states that "the Directors have secured the services of Messrs. Hammond and Co., of London, as the Electrical Engineers of the Company for the construction of the works;" and Clause 8 states that "tenders will be invited from leading Electrical Contractors for carrying out the work.")

MISCELLANEOUS.—Pollit and Wigzell (Limited), capital £40,000, in £10 shares. Copley, Turner, and Co. (Limited), capital £50,000, in £10 shares.

CITY NOTES, &c.

BENGAL TELEPHONE COMPANY (LIMITED).—The report of this Company for the year 1891 shows that the position of this Company is improving. An available balance, amounting to Rs.54,676 is shown at the credit of profit and loss account, out of which it is proposed to pay a dividend at the rate of 5½ per cent., and to carry forward Rs.6,276. The report states that, on December 31st last, the Company's revenue had amounted to Rs.78,155, the largest on record.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—Notice is given of the proposed drawing of 168 of the Five per Cent. Debentures (1884 issue) of this Company, which will take place at noon on Monday next, the 11th inst., at the offices of the Company, Winchester House, Old Broad-street, London, E.C.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended April 4th were £796, as against £901 for the corresponding period of last year (Easter week), showing a decrease of £116. The total receipts to date, from January 1, 1892, are £11,342, against £10,084 for the corresponding period of 1891, an increase of £1,258.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of March were £4,000, as compared with £4,002 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the month of March amounted to £2,103, as compared with £1,930 in the corresponding period of last year, an increase of £173

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of March amounted to £59,037, as against £58,447 in the corresponding period of last year, an increase of £590.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—In our advertisement columns will be found particulars of the drawing of 337 Debentures of £100 each, of the Five per Cent. Australian Government Subsidy Debentures. These debentures will be paid off at par on July 1st next at Messrs. Barclay, Bevan and Co.'s, 54, Lombard-street, E.C., and interest will cease after that date.—The accounts of the Company to December 31st last show, subject to audit, a balance of profit of £193,237. 2s. 2d., after payment of three interim dividends. The Directors now propose to distribute on May 4th the usual dividend of 2s. 6d. per share, making a total dividend of 5 per cent. for the year 1891, together with a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the year. The balance of £111,957. 2s. 2d. has been carried to the reserve fund. The share register will be closed from April 28th to May 4th, both days inclusive.—The traffic receipts of this Company for the month of March amounted to £43,805, and to £44,716 in the corresponding period of last year, a decrease of £911.

GATTI'S ELECTRIC LIGHTING STATION.—Rumour has it that this concern is to have the advantage of limited liability shortly.

GLOBE TELEGRAPH TRUST COMPANY.—The Directors have declared an interim dividend of 3s. per share on the preference shares, and of 2s. 6d. per share on the ordinary shares.

GREAT NORTHERN TELEGRAPH COMPANY (LIMITED).—The traffic returns of this Company in March, 1892, were £22,000; 1st January

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to 31st March, 1892, £62,800; corresponding month, 1891, £64,400; 1890, £60,200.

ELECTRIC CONSTRUCTION CORPORATION.—Mr. W. W. Duncan, in his report for April, deals at considerable length with the subject of electric traction, and again dwells upon the value of Electric Construction Corporation Debentures as an investment.

SUBMARINE CABLES TRUST.—Notice is hereby given that a payment of £1. 2s. 6d. will be made on account of the coupon due on April 15th, on and after 16th inst., by Messrs. Glyn, Mills and Co., Lombard street The coupon should be left with the bankers for examination four clear days before payment.

TELEPHONE COMPANY OF AUSTRIA.—A dividend is announced at the rate of 6 per cent. per annum on the preference shares of this Company for the past half-year.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the fortnight ending March 31, 1892, amounted to £3,047, as compared with £3,046 in the corresponding period of last year, an increase of £1.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ending April 1, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,265.

W. T. HENLEY'S TELEGRAPH WORKS.—Warrants have been posted for a dividend at the rate of 7 per cent. per annum on the preference shares and of 5 per cent. per annum (free of income-tax) on the ordinary shares of this Company, for the year ended December 31st last. The subscribed share capital of this Company is £21,000 preference shares and £67,270 ordinary shares.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, March 30.		Price Wednesday, April 6.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending April 6.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	16/0	Anglo-American	49½	50½	49½	50½	4 19 0	Jan., Apr., July, Oct.	..	..
£2,849,510	Stock	3 2/0	Do. Preferred	88½	89½	88½	89½	5 17 4	" "	89½	88⅝
£2,849,510	Stock	5/0	Do. Deferred	11½	12	11½	12	..	" "	11⅝	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	..	..
130,000	£10	3/0	Brazilian Submarine xd	10¾	11¼	10¾	11¼	7 2 3	Mar., June, Oct., Dec.	11¼	10⅝
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	155	160	155	160	4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	10½	11⅛	10½	11⅛	6 19 2	February and August	11 1/16	..
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid) xd	3½	3⅞	3½	3⅞	6 18 8	April and October	..	..
6,000	5	10%	Do. Preference 10% xd	8½	9⅞	8½	9½	5 5 3	" "	9½	..
60,710	20	3/6	Direct United States	11⅛	11⅝	11⅛	12½	5 12 0	Jan., Apr., July, Oct.	11 1/16	11⅛
400,000	10	2/6	Eastern	14⅞	15	14⅞	15	4 3 4	" "	15	14⅞
70,600	10	6%	Do. 6 per Cent. Preference	15	15½	15⅛	15⅜	3 16 2	" "	15⅛	15⅛
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108	111	109	112	3 11 5	May and November	111	109½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	108	107½
250,000	10	2/6	Eastern Extension	14⅜	15⅛	14⅞	15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	14⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	106	109	107	110	3 12 9	February & August	109	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102	105	102	105	4 15 3	January and July	104⅛	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101	104	101	104	4 16 2	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99	102	99	102	3 18 5	February & August	101⅛	101
180,227	10	1/6	Globe Telegraph and Trust	9⅞	10⅛	10	10½	4 17 7	Jan., Apr., July, Oct.	10⅛	10
180,042	10	6%	Do. 6 per Cent. Preference	14½	15⅛	15	15½	3 18 8	" "	15½	15
150,000	10	5/0	Great Northern	18⅞	19½	18⅞	19½	4 8 4	Jan., April, and July	18⅛	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	42½	42
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	7½	8	7	8	5 3 2	April and October	..	..
3,381	£100 Cert.	6%	Submarine Cables Trust 6%	115	120	116	121	4 19 2	" "	..	..
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	100⅛	..
30,000	10	2/0	West Coast of America	3½	4½	3½	4½	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	..	..
88,321	10	1/0	West India and Panama	1⅝	1⅞	1⅝	1⅞	..	" "	1⅞	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10½	10⅜
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8½	9½	8½	9½	6 6 4	" "	9½	..
67,007	15	6/0	Western and Brazilian	10	10½	10	10½	7 2 10	" "	..	..
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 3	" "	6½	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4	4½	4	4½	..	" "	4½	4½
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	104	107	5 12 2	February & August	..	..
€237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	104	107	5 12 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	97	100	97	100	6 0 0	March & September	..	..
			TELEPHONES.								
324,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜	½	⅜	½	8 7 7	May and November	..	..
x20,000	£1	4·76d.	Oriental (11s. paid)	⅛	⅜	⅛	⅜	6 8 11	Yearly	..	..
438,984	5	2/6	National	4⅜	4⅝	4⅜	4⅝	6 9 9	June and December	4 1/16	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13½	12½	13½	4 8 11	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	11½	12½	11½	12½	4 16 0	" "	12 1/16	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	105	107	106	108	4 3 4	January and July	107⅛	106⅛
58,000	5	1/0	United River Plate	2	3	2	3	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	.. "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£8 paid)	7½	8	7½	8	..	—	7⅞	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
8,332	£5	..	House to House Electric	2⅞	3⅛	..	..	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5⅝	6	..	..	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5⅛	6	..	..	..	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 paid)	2⅝	3	2⅝	3	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5	5⅛	5	5⅛	..	March	..	..
111,000	5	..	London Electric Supply	⅞	1⅛	¾	1	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8⅞	9	8¼	8⅝	..	..	8⅝	8⅜
6,318	10	..	Notting Hill Electric Lighting (fully paid)	3½	4⅛	4	4⅛	—	..	3⅝	..
18,680	£5	5/0	St. James' and Pall Mall	8	8⅜	8½	8⅝	—	..	8⅜	8⅜
7,900	£5	7%	Do. 7% Preference	7½	7⅞	7½	7⅞	..	..	7⅞	..
42,853	5	..	Westminster Electric Supply (fully paid)	6½	6⅝	6½	6⅝	..	..	6 1/16	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1·9	Brush Electrical Engineering	3½	3⅝	3	3½	..	..	3½	3½
69,996	2	6%	Do. 6 per Cent. Preference	2⅜	2⅝	2	2½	5 2 7	..	2⅝	2 1/16
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5½	6	5½	6	5 16 8	January and July	5 1/16	..
17,130	5	17½	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	12/0	Electric Construction	5⅞	6½	5⅞	6½	..	—	6⅛	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜	2⅝	2⅜	2⅝	..	—	5 1/16	5⅛
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	—	2 1/16	2½
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	19½	20½	20	21	4 15 3	February & August	..	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	105	102	105	4 5 9	March & September	20 1/16	20
11,334	£10	6/4	International Okonite Limited Ordinary	4	5	4	5	..	..	..	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅜	½	⅜	½	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	4	4½	3¾	4¼	9 0 9	May and November	4	..
36,250	12	36/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 1	March and July	44	42⅜
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	½	¾	..	..	4 10 0	..	..	..
—	£5	8%	Do. Preference (fully paid)	2¼	2½	..	..	11 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
50,000	£10	—	City and South London Railway	2½	3½	2½	3½	..	—	3½	2½

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THE ELECTRICIAN:

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NOTES.

Since the classical researches of Hertz, a number of physicists have attempted to get accurate quantitative results with electrical oscillations. The formulæ used by Hertz were confessedly only approximations, as the phenomena are far too complex to be treated in any simple manner. Many difficulties have therefore been encountered before reliable measurements could be obtained, and the merit of surmounting these obstacles is mainly due to French physicists. The latest researches in this direction are those of M. Blondlot, whose work has just received an important testimony to its value in the form of a report presented to the Académie des Sciences by MM. Fizeau, H. Becquerel and Poincaré. The distribution of currents and potentials in such rapid oscillations seems to differ entirely from what obtains for slow alternations, so that the capacity and self induction calculated from ordinary formulæ only appear to hold in special cases. M. Blondlot has succeeded in constructing receivers and resonators in such a way that the ordinary formulæ hold, and has thus been able, not only to obtain reliable measurements, but also to carry out a valuable investigation about the nature of the oscillations themselves. Those who were present at Mr. Tesla's recent lecture will remember his pointing out that the air effects which took place at the surface of the conductors considerably modified the value of their capacity, and accordingly that calculations based on the ordinary capacities would lead to erroneous conclusions. If these effects occur with such comparatively slow alternations as 10,000 per second it is only natural to assume that they will be still more marked with Hertzian oscillations which are 10,000 times as frequent as those used by Mr. Tesla. The wonder rather is that M. Blondlot has succeeded so well.

The reduction in fees for renewal of patents, which was announced in the Budget speech on Monday last, will be hailed with satisfaction by many of our readers. For ourselves, we have not altogether sympathised with the cry for cheaper patents. On the one hand, even the total sum of £154, which has hitherto been the cost of a full fourteen years' term, is but a small fraction of the expense of working a patent of any importance; while, on the other hand, it may be argued that if a patent has not turned out at the end of four years to be worth renewing at an annual fee of £10, it is better that the monopoly should be stopped, in order that other persons may have an opportunity of making something of the invention, if the patentee or proprietor of the patent cannot do so. The effect of the reduction will be to increase the number of small and comparatively unimportant patents, which would otherwise be extinguished. It is estimated that a loss of revenue of "£50,000 for a full year" will be incurred, but there is little doubt that the ultimate effect will be to increase the income of the Patent office. The saving amounts to £51 on a complete patent. Nothing can be more simple to remember than a payment of £4 for the first four years, £5 on the fifth year, and so on, up to £14 for the last year. The patent agents will, of course, spoil the symmetry of this.

According to the *Western Electrician* of April 2nd the Thomson-Houston Company has finally agreed to furnish 2,500 arc lights for the Chicago Exhibition at $20 each, promising to furnish 1,000 more at the same rate if called upon to do so. On their part the Exhibition authorities have agreed that the Thomson-Houston Company shall not be required to furnish any superintendence or help of any kind in the working of the plant. The Standard Electric Company of Chicago are to be given 1,000, and the Western Electric Company 500 lights on the same basis. Thus 5,000 out of 6,000 lamps are provided for. "There is still some talk of seeking the remainder from foreign sources," says our Chicago contemporary, adding that the whole arrangement gives general satisfaction, and all concerned appear to be glad that an agreement has been reached. The deadlock, therefore, to which we alluded last week has thus been removed.

In the lecture which was delivered by Mr. Preece at Liverpool last week, and which we publish in the present issue, a 16-candle 100-volt lamp is assumed to take 0·48 ampere. Knowing that the lamps which are in use in this country take fully 4 watts to the candle even when quite new, we inquired from the author why he took such a favourable estimate. His reply was that while at present it may be most economical to run glow lamps at the degree of incandescence recommended by the manufacturers, the day is rapidly approaching when we may hope to buy lamps at about half the present price. Assuming that the filaments are equal to the present ones, it will not only not be extravagant to run them higher, but, if the present practice is correct, it will be more economical to do so. In speaking of the present quality of filament we hear from several quarters that there have been either some bad batches of lamps of late, or their quality has

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deteriorated. There have been complaints about short-lived lamps, and these of lamps which last not 600 or 700 hours instead of 1,000, but which break down after a week or two of ordinary domestic lighting. It is only fair to say, however, that the Edison Swan Company investigate these complaints, and substitute fresh lamps if the fault is in the lamp. The staff at Ponders End are no doubt well advised in trying to make an eighteenpenny lamp, but they should take care that these are not put on the market until they are wanted.

Of the various waste forces of Nature to which Mr. Preece has been giving his attention, the "roaring torrent" seems to be most easily persuaded to yield some of its energy to industrial purposes. The utilisation of the power of a flowing river with any reasonable economy is a matter of some difficulty, unless in such exceptional cases as the Rhone or the Rhine, where floating mills are to be found. The least promising force, on account of the heavy cost of plant, is the tide. The word "efficiency" has been sadly misused at times, but Mr. Preece's expression of the efficiency of the transmission of energy by transport of coal is not only correct but original. Even though the efficiency as reckoned from the price of coal at the pit's mouth and the price when delivered at the central station may be only some 25 per cent., there is not at present much inducement to remedy this by transmission of the energy by wire instead of by railway. The Westminster Electric Supply Company will be able to estimate before long the difference between the cost of fuel at their river side and mid-London stations. The capitalised value of the difference will no doubt be considerable.

A calculation ascribed to Mr. Kapp which is quoted by Mr. Preece in his lecture, states that if 10,000,000 H.P. were taken continuously by tide-mills from the energy of the earth, the length of the day would be increased by one second in a century. We made a similar calculation some years ago, and find a note of the figure $8{\cdot}7 \times 10^{22}$ H.P., but have not repeated the calculation. There are about 10^{33} foot-pounds of energy to draw upon, and if our figure and that of Mr. Kapp differ a thousand-billionfold it does not very much matter.

In an article on Coast Protection in the *New Review* for this month, Prof. Tyndall severely criticises the performance of our lighthouses and fog signals, and makes special allusion to the apparatus at St. Catherine's Point. Beginning with the siren, he complains that air has been used instead of steam, and from experiments made at South Foreland, concludes that if steam had been employed on the night of February 2nd last the siren would have made itself heard by the crew of the Eider. Prof. Tyndall gives no reason for preferring steam to air, and loses sight of the ease with which the latter can be stored. Four large cylinders constructed like boiler shells are kept charged with compressed air at St. Catherine's Point, and these, in case a fog comes on suddenly, are able to supply the siren for some fifteen or twenty minutes until steam is raised in the boilers. The boilers are, of course, always under steam, but the fires are banked in the morning when the dynamos are stopped. There is no fear that these air reservoirs will be forgotten and allowed to run down, for the air is employed every night to drive a tiny engine for revolving the optical apparatus. A more uniform, less troublesome and cheaper mode of driving it is difficult to conceive.

Prof. Tyndall's most practical suggestion is the recommendation of flashing; an altogether different thing to a revolving light. Even the flash of signal guns is frequently seen when their reports are inaudible, and the light of the lighthouses with which they are associated is invisible. He contends that by the dispersion and diffusion of fog particles, the spaces between the beams of a revolving light become as luminous as the beams themselves. The revolution of the optical apparatus of a lighthouse, after all, only results in more or less sudden outbursts of light, as far as any distant observer is concerned. Exactly the same effect would be produced by the intermittent extinction or sudden shading of the light; but there would be no blurring of the intervals during thick weather, and even if the direct light could not penetrate the fog, a sharply intermittent glare would be seen. The essence of Prof. Tyndall's idea is, in fact, the substitution of time intervals for space intervals.

Prof. Tyndall very properly objects to the six or seven million candle power which astound the readers of newspapers, and points out that the 730 candle power of the oil light which preceded the electric light at St. Catherine's Point was obtained by direct photometric measurement, while the seven million was derived from calculation. We have already pointed out the absurdity of such figures in these columns, and would remind our readers that at the South Foreland experiments the light was found to be between 10,000 and 30,000 candle power, according to the current and the number of dynamos employed. We have plotted current against candle-power, and find that for these large currents from 50 to 70 candle-power is given for every ampere.

Royal Microscopical Society.—This Society will meet on Wednesday next, at 8 o'clock.

Accumulators in Telegraphy.—Accumulators have entirely displaced primary batteries at the Milan Central Telegraph Office.

Bradford.—At a meeting of the Town Council on Tuesday last, it was decided that the price of electricity should be reduced from 6d. to 5d. per unit, from the 1st inst.

Portsmouth.—The Town Council have applied to the Local Government Board for power to borrow £60,000 for lighting the borough with electricity. There is said to be a strong feeling existing against the scheme, and the application will, it is stated, be strenuously opposed at the public inquiry.

Royal Meteorological Society.—At a meeting of this Society on Wednesday next, at 7 p.m., the following Papers will be read:—"Anemometer Comparisons," by W. H. Dines, B.A.; "The Hurricane over the West Indies, August 18—27, 1891," by Francis Watts.

The Government Grant to the Royal Commission.—The Government have agreed to increase the grant to the British Commissioners for the Chicago Exhibition, from £25,000 to £60,000. This will enable the Commissioners to offer space to British exhibitors free of charge.

Coast Communication.—Sir Edward Birkbeck has accepted an invitation from the Plymouth Chamber of Commerce

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to a banquet to be given in his honour, on Thursday in Easter week, in recognition of his services in connection with the subject of electrical communication around our coasts.

Huddersfield.—On Thursday last week Mr. Rienzi Walton, M.Inst.C.E., held an inquiry relative to an application by the Huddersfield County Council for sanction to borrow £50,000 for electric lighting purposes. The Town Clerk stated that the ratable value was £422,873, and the total indebtedness of the borough was £2,067,069. There would be provision for 6,660 8 c.p. lamps. The Inspector said that as the matter was of an urgent nature he should do his best to expedite it.

Presentation.—The retirement of Mr. C. Wilson from the position of superintendent of the Cadiz station of the Spanish National Submarine Telegraph Company was made the occasion, a few evenings ago, of presenting him with a gold watch, and Mrs. Wilson with a gold bracelet. The presentation was made at the club rooms, and a number of the members of the English colony were present. Mr. Wilson leaves Cadiz to occupy a similar post at Pernambuco for the South American Cable Company.

Telegraph Rates to India.—In reply to Mr. Henniker Heaton Sir J. Fergusson stated, in the House of Commons, on Monday night, that he had no intention of proposing a reduction of rates and guarantee in regard to India, similar to that lately come to between some of the Australian colonies and the Eastern and Eastern Extension Companies. He had reason to believe that the conditions of commercial life in India would not produce any increase of business commensurate to, or approaching, the loss of revenue which would be the result.

Gas Concessions in France.—A deputation from the Chambre Syndicale des Industries Electriques recently waited on the Minister of Public Works, and laid before him a peculiar difficulty under which the electric lighting industry labours in France. A large number of townships, in order to obtain gas on favourable terms, have granted gas concessions, which prevent any other illuminating company from taking up the local roads for the purpose of laying mains; and now recent decisions of the Conseil d'État threaten to apply the same law to the public highways. The deputation asked that electric light mains should, at least, be permitted under the roads owned by the State.

A Sub-Lacustrine Cable.—A little submarine cable experience is evidently wanted by the Wurtemberg and Swiss telegraph officials. Some time ago an attempt was made to lay a cable in Lake Constance between Romanshorn and Friedrichshafen, for the purpose of connecting the Swiss and Wurtemberg telegraph systems. Although the distance is only 13 kilometres, the attempt failed, owing to the cable having been allowed to run out too quickly, with the result that the ship was still 2 kilometres from the shore when the cable came to an end. The same thing frequently happened in the early days of submarine telegraphy—notably, in the case of the cables laid to Algiers by the French Government.

Large Current Batteries for Experimental Work.—Those who want to work induction coils at odd intervals, says *Industries*, always find the battery troublesome. They use bichromate cells, or various kinds of batteries with queer depolarising liquids, and find them all equally objectionable. Every electrician knows all about Planté batteries, but one is inclined to wonder how often they are used for this kind of work. Nothing can be simpler than to use a few small current cells with a little secondary battery in parallel. There is then no trouble, and for intermittent and occasional work a large current can be obtained. It may seem rather late in the day to mention such a thing as this, but the obvious is frequently overlooked.

The Influence of Tempering on the Thermo-Electric Properties of Bismuth.—G. P. Grimaldi states in *Il Nuovo Cimento* (Vol. XXV., p. 40), that lengthy investigations of the thermo-electric behaviour of pure and impure bismuth lead him to conclude that the thermo-electric power of bismuth free from tin is but little impaired by tempering. On the other hand, if the bismuth contains even a small trace of tin, tempering has a marked effect, increasing with the proportion of tin present. In a sample containing 1 per cent. of tin, the thermo-electric power diminished 47 per cent. Successive heatings cause the impure material to gradually regain its normal value. The couple employed was a copper-bismuth one.

Reduction of the Patent Office Fees.—In his Budget speech on Monday evening, the Chancellor of the Exchequer made the following important announcement with regard to the scale of patent fees to be enforced in the near future. The primary fee of £4 for the first four years will be continued, but from that time onwards the following large reductions will take place:—The fees for the fifth, sixth, seventh, and eighth year will be £5, £6, £7, and £8 respectively, in lieu of £10, as hitherto. In the ninth and tenth years the fees will be £9 and £10, in lieu of £15, as hitherto. During the last four years the fees will be £11, £12, £13, and £14, as against £20. These reductions, which will come into force on September 20th, are estimated to involve a diminution of £50,000 per annum in the Patent Office receipts.

Electric Launches at the Chicago Exhibition.—Tenders for the exclusive privilege of operating passenger boats to be propelled either by electricity, steam, or naphtha, on the lagoons of the Exhibition grounds, were recently opened. Three of the tenders, says the *Western Electrician*, were for electric launches. General C. H. Barney, representing the Electric Launch Navigation Company of New York, offered to construct and operate from 20 to 60 boats 34ft. long, and pay the Exhibition 33⅓ per cent. of the gross receipts. The Columbian Launch Company of Chicago offered the Exhibition 31 per cent. of its gross receipts. This Company proposed to use either electricity or steam. D. R. Proctor, of Chicago, offered to furnish boats operated either by electricity or steam, giving the Exhibition 33⅓ per cent. of the gross receipts.

Glasgow.—At a meeting of the Police Commissioners on Monday last, it was decided to light some nine or ten streets by electricity. The total number of lamps erected will be 106. In moving the approval of the minutes, the Chairman of the Watch and Lighting Committee said that they had a report from the inspector of lighting as to the cost of lighting those streets with electricity, and they found that it amounted to £2,120. To that was to be added a capital expenditure of £2,500 for new electric lamps. It was proposed to wipe off this payment of £2,500 in ten years, which would make the annual cost of the electric light £2,371, or an increase, speaking roughly, of £700 on the present annual expenditure; but the committee were satisfied that this was entirely warranted by the great improvement it would be in the city.

The Proposed Niagara-Buffalo Transmission.—The Oerlikon Company, says *Industries*, has sent in a tender for the construction of the proposed transmission plant between Buffalo and Niagara Falls, a distance of 22 miles. Three-phase currents are to be used. The power to be transmitted is 5,000 H.P. The dynamos, which will be of the multipolar drum-wound armature type, are to be coupled directly to the shafts of the turbines, making 250 revolutions. The proposed pressure is between 600 and 700 volts, and it is to be converted into 25,000 volts before passing to line. The Oerlikon Company propose to use two lines, one for lighting and the other for power; the cost of these is to be £4,000. The guaranteed efficiency of the generators is 96 per cent., and that of the whole line up to the second set of transformers is to be 84 per cent. The total cost of the installation, including exciters and generators and line, is to be £36,000.

Massachusetts Street Railway Statistics.—The second annual report of the Board of Railroad Commissioners of Massachusetts, just issued, gives some very interesting statistics in regard to street railways in that State. The report summarised gives the following statistics for the year ended September 30, 1891:—Aggregate capital of all street railway companies, $19,553,952; total miles of track, 674.13; total cost per mile, $41,763; passengers carried, 176,090,189; average receipts per passenger, 5.06 cents; average cost, 4.05 cents; profit, 1.01 cents against 1.10 cents the previous year. Number of accidents 409, fatal 29. There were 204 accidents on the West End Street Railway system of Boston, 14 of which were fatal; 122 accidents occurred by horse cars and 82 by

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electric cars. On September 30th, there were in the State 279.44 miles of electric roads, &c., using the "overhead" system an increase of 128.16 miles, and 9.59 miles using storage batteries. There were under construction 13.3 miles on the "overhead" system.

The Commelin-Finot Cadmium Accumulator.—The positive plate of this accumulator, says *L'Industrie Electrique*, is an ordinary Julien positive; the negative plate being preferably an alloy of lead, cadmium, and antimony. The liquid is a solution of sulphate of cadmium, to which 10 per cent. of sulphuric acid is added. MM. Commelin and Finot also propose to employ a positive plate formed of twisted lead strip, holding plugs of lead chloride. On charging, the oxygen oxidises the positive plate as usual, and metallic cadmium is deposited on the negative plate. On discharging, the cadmium combines with the sulphuric acid, cadmium sulphate being re-formed, and the hydrogen liberated from the sulphuric acid goes to the positive plate and reduces the peroxide. The inventors anticipate by this arrangement the complete avoidance of sulphating. The electromotive force of the cell is stated to be 2·5 volts on open circuit, and from 2·2 to 2·15 volts during discharge. The output per pound of plate is 24·5 watt hours.

The Grounding of the Neutral in the Three-Wire System.—"It has been for some years past," says the *Electrical Engineer* of New York, "the general practice among companies operating low-tension three-wire circuits, more particularly among the various Edison illuminating companies in the country, to ground the neutral. This practice was introduced in a few stations as an experimental protection against lightning, and for a long time met with no opposition on the part of the underwriters; but it would appear that a recent fire in New York has brought forward prominently the question of the possible dangers involved in this practice. The New York Board of Fire Underwriters, at their last meeting, went even so far as to pass a resolution requiring the electric companies to remove all such grounds now existing on their circuits before October 1, 1892, and to make regular weekly reports of the tests of their circuits as called for in the requirements of the Board, failing in which the superintendent of the Survey Department is directed to decline to grant certificates."

Post Office and Telegraph Profits.—The following extract from Mr. Goschen's Budget speech will be read with interest:—"The Post Office increase is £611,000, of which £490,000 is due to an increase in salaries and wages. That is how our estimates are swollen; and, while the Government have been anxious to meet the fair and equitable claims of those who are employed in that service, we have endeavoured to deal with the subject at the same time in a spirit of proper economy. Now, as regards telegraph services, one observation I commend to some postal reformers. The average profit in every £1 of telegraph receipts during the last five years has been 3d. The expenses have been 19s. 9d., and the profit 3d. During the previous five years the expense was 18s. 6d., and the profit 1s. 6d. We have now come down to this position, that the increase of telegraph communication and the further facilities as to addresses, so dear to some postal reformers, will probably leave us in a deficit. The increased postal revenue, which may be called £350,000 a year, is far more than balanced by the increase in expenses, and the margin of revenue at the disposal of the Exchequer is rapidly being diminished. The gross incomes of the Post Office and Telegraphs for the financial year 1891-92 amounted to £12,630,000, or £30,000 more than the estimate."

The Application of Electricity to Mining.—At a recent general meeting of the members of the South Staffordshire and East Worcestershire Institute of Mining Engineers, a discussion took place upon Mr. L. B. Atkinson's Paper on this subject. Mr. R. S. Williamson and Mr. W. Wardle contributed short practical Papers on the same subject, giving their experience of the use of electrical machinery. Mr. Williamson stated that so far as his experience went he found that there was less trouble with electricity than with compressed air, and that for working a long distance from the shaft the former was of much greater utility. Mr. Wardle dealt with the approximate cost of electricity as a motive power compared with compressed air, remarking that the cost of laying down plant for electricity in a mine with which he had been connected was £1,000, whilst he estimated that the cost of compressed air appliances would have been £2,156. The Chairman (Mr. W. F. Clark) said he took it that the general opinion was that electricity was the most efficient power when work had to be done a long way from the shaft, and it seemed to him that electricity for that purpose had given compressed air its deathblow. Mr. Collis said they had come to the conclusion that electricity would supersede compressed air for work a long way from the shaft, but that it would not compare with the use of ropes worked from the surface.

The Oxford and Cambridge Boat Race.—A conspicuous feature of the University Boat Race this year was the electric launch fleet. The charging station of the General Electric Power and Traction Company was crowded with visitors, as were also Messrs. Woodhouse and Rawson's, and Mr. Sargeant's barges. We learn from the General Electric Power and Traction Company that the electric launch season has opened well.—The Boat Race, as reported by the Exchange Telegraph Company this year, was a marvel of telegraphy, the progress of the boats at intervals of a few minutes along the entire course having been published all over London almost as the crews were passing the points indicated; and immediately following the result there was despatched a complete description of the race from start to finish, which was in the hands of the newspapers and others provided with that Company's instruments long before a single Pressman was able to land his "copy" from the Press boat at Mortlake, and also long before the pigeons despatched from the scene were able to settle down in an homeward direction. The Press boat, as it steamed up the Thames, paid out a cable consisting of a 7-strand conductor, insulated with vulcanised rubber with warps and braids of flax, which had been manufactured by Messrs. Walter T. Glover. The instruments used were Morse sounders. In consequence of this enterprise, the London papers containing the result and full details of the race, were on sale within four minutes after the Oxford crew had passed the winning post. Between 12.8 and 12.37 no less than 13 messages were sent, beginning with the announcement of the winner of the toss, and ending with a short description of the race, containing over 150 words. We learn that some 18 years ago a similar experiment was made.

Power Generators for the Chicago Exhibition.—On March 18th the tenders for the furnishing of power generators for the motor service in the Chicago Exhibition were opened. Five bids were received, says the *Western Electrician*. The Eddy Electric Manufacturing Company of Windsor, Conn., offered to furnish the 300 H.P. generating apparatus for the transportation building free of cost. The National Electric Manufacturing Company of Eau Claire, Wis., offered to furnish the apparatus for this building for $2,500. The Western Electric Company proposed to furnish about 400 H.P. for $6,500. The Mather Electric Company of Manchester, Conn., bid on the mines building, and offered to furnish 600 H.P. for $2,450. The Thomson-Houston Company put in a bid for furnishing all the apparatus (2,500 H.P.) for $52,900. This company also asked for the exclusive right of furnishing exhibitors such power as might not be included in the general plant, and charge therefor $40 per H.P. It also wanted the sole right to furnish all supplies, and the right to sell or lease meters for the measurement of the amount of power used.—According to latest advices, all the tenders save that of the Eddy Company have been rejected. The Grounds and Buildings Committee have adopted a recommendation that this Company should be offered the privilege of furnishing from 1,000 to 1,500 H.P., at the rate of $2.50 per H.P. In the event of the Company agreeing to furnish 1,500 H.P. capacity on the terms mentioned, all other firms wishing to supply generators for the World's Fair plant would have to do so free of cost. In case, however, the Eddy Company chooses to supply but 1,000 H.P., the Mather Company will be given an opportunity to furnish the capacity mentioned in its bid at the rate of $2.50 per H.P.

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SOME RECENT RESEARCHES ON ELECTRICAL OSCILLATIONS.*

BY MM. BLONDLOT AND DUFOUR.

In order to obtain satisfactory results with electrical oscillations, M. Blondlot advises the use of a special form of exciter devised by himself. This consists of a condenser formed of two circular discs, α and β (Fig. 1), about 12cm. in diameter, placed at 1cm. distance from each other. To these plates are soldered two copper wires, $\alpha\ \gamma$, $\beta\ \delta$, 3mm. in diameter, terminating in balls, γ and δ, and bent so that each forms a semicircle of about 2 metres in diameter. The balls γ and δ are connected with the poles of an induction coil, so that when the latter is worked an oscillating current is set up in the circuit $\alpha\ \gamma\ \delta\ \beta$, across the air gap $\gamma\ \delta$.

The secondary circuit is formed of a copper wire bent in a circle whose diameter is less than that of the primary by about 1cm. This wire is enclosed within an india-rubber tube and lies beside the primary. Its position is indicated in Fig. 1, by the dotted line. It terminates in two points M N, situated near the spark gap $\gamma\ \delta$. The sparks which are induced between M and N are, in certain cases, longer than those in the primary circuit, and M. Blondlot has succeeded in obtaining sparks in this way as long as 11mm.

To transmit oscillations to a distance, two long parallel wires are soldered to M N, and the field between them is explored by means of a resonator.

Several advantages are secured by the use of this type of oscillator. The phenomena are intensified and are thus more

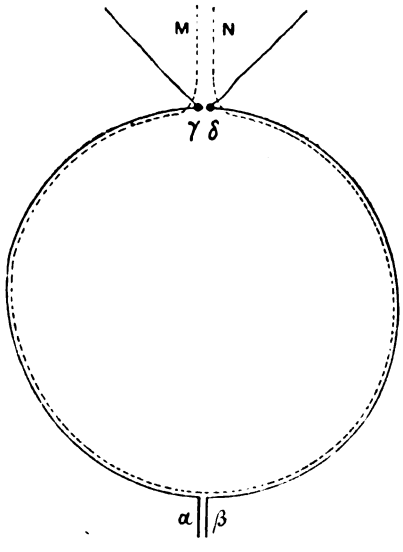

FIG. 1.

easily observed. The primary spark is always oscillatory, even though the balls $\gamma\ \delta$ are left unpolished. The period of the exciter can be readily changed by adjusting the distance between the plates $\alpha\ \beta$ of the condenser, and the greatest advantage of all is that troublesome electrostatic effects,† due to charges on the surface of the wires, are overcome.

To increase the action of the resonator the following device is resorted to:—The parallel wires M N′, N N′ are laid at a distance of about 2cm. from each other, except where the resonator is placed. Here (as indicated in Fig. 2) the wires are bent into the shape of a rectangle, $C_1\ D_1\ E_1\ F_1$, a little larger (about 0·5cm.) than the resonator C D E F. With this arrangement the inductive effects are very strong. As, however, the resonator cannot easily be moved along the wires M M′ and N N′ the wave-lengths are determined by the method of movable shunts already described.‡

By making use of the above form of exciter MM. Blondlot and Dufour have been able to carry out some important experiments, showing the effect of a want of symmetry in the circuit on the mode of propagation of the electric waves.

* Abstracted from the *Comptes Rendus*, February, 1892.

† *See* V. Bjerkness, *Wied. Ann.*, Bd. XLIV., p. 520.

‡ See *Journal de Physique*, Vol. X., p. 554.

The apparatus they used is illustrated in Figs. 3 and 4. The fixed resonator is placed at R S, and the adjustable shunt is indicated by $\mu\ \nu$. The experiments consisted in finding by trial the position of the bridge $\mu\ \nu$, for which the spark of the resonator disappeared. The length of the wire R $\mu\ \nu$ S in this case was the half-wave length.

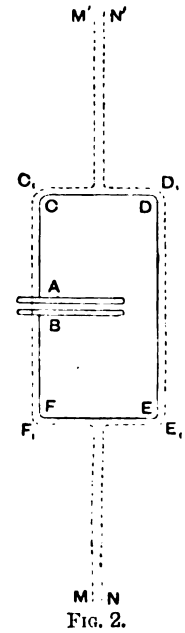

FIG. 2.

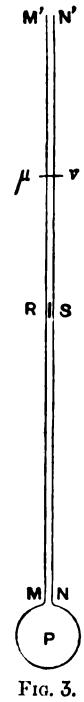

FIG. 3.

To show the effect of dissymmetry, the wire N N′ was cut near the point N, and two parallel wires N K were soldered to the two points so formed. The length N K was adjustable at will.

In this way the authors have established the fact that the length of the loop N K has no influence whatever on the position of the bridge $\mu\ \nu$, for which the resonating spark disappears, or in other words that *the wave length as measured by the resonator is independent of the dissymmetry of the two wires which transmit the electro-magnetic waves.*

The experiment was repeated many times under most diverse conditions. The length of the loop N K was varied from 0 to 30 metres without observing any appreciable change in wave length. In the extreme case the length N ν was 42 metres, while M μ was only 12. The capacity of the resonator was also changed without apparently altering the wave length.

These experiments are in accordance with those of Sarasin and de la Rive. The latter showed that the wave length was independent of the exciter, while these show that the conductors transmitting the undulations have no influence on the wave length so measured.

The theory of resonance to which independent support is given by M. Bjerkness' experiments* for the case of propagation through air, when adapted to the case of propagation along wires, can be thus stated. Each wave communicates two impulses to the resonator, the first by direct propagation along

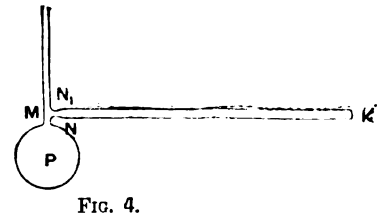

FIG. 4.

the wire, the second after the wave has travelled across the bridge to the other wire. The second impulse reinforces or annuls the first, according as the resonator during the interval has performed an even or uneven number of half vibrations. This only depends on the length R $\mu\ \nu$ S, and not on the symmetry of the circuit.

* V. Bjerkness., *Wied. Ann.*, Bd. XLIV., p. 93.

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According as the waves travelling along the two wires are in phase or out of phase at the resonator, the resonance effect for a position of the bridge other than that of extinction will be more or less intense. M. Poincaré has pointed out that the phenomena will be most strongly marked when the length of the loop N K is 0, λ, 2λ, ..., and least apparent when this length is $\frac{\lambda}{2}$, $\frac{3\lambda}{2}$, &c. This, in fact, is what the experiments show.

M. BLONDLOT'S RESEARCHES ON HERTZIAN OSCILLATIONS.

The following is a translation of a report recently presented to the Académie des Sciences by MM. Fizeau, H. Becquerel, and Poincaré relative to a memoir by M. Blondlot, in which he details his researches on Hertzian oscillations.

The memoir about which we have the honour to report to the Académie contains a large number of important results relating to Hertzian oscillations. In the numerous researches which have had Hertz's discovery as their point of departure, use has often been made of a formula due to Sir W. Thomson, according to which the period of an oscillatory discharge is equal to a constant factor 2π, and to the mean proportional between the capacity of the condenser and the self-induction of the wire connecting the coatings. This formula, deduced from theoretical considerations, had not received the corroboration of experiment in a sufficient manner. Previous verifications related only to oscillations much too slow; and we might question whether it was legitimate to apply the formula to oscillations the period of which is less than the one hundred millionth of a second. The experiment of M. Lecher, which stood, moreover, by itself, and was very indirect, had given rise to several objections. The work of M. Blondlot fills this gap.

As we know, Hertz in his first experiments made use of apparatus consisting of three essential parts—an exciter, a system of two long metallic wires, and a resonator. M. Blondlot introduced important modifications into each of these three parts, for the purpose either of reinforcing the effects obtained, or of facilitating the measurement of the capacity and self-induction of the resonator. The exciter consists of a condenser, the coatings of which are united by a circular wire containing a spark gap. By altering the distance apart of the plates, it is thus possible to vary the capacity and obtain a more perfect resonance. The excitation is transmitted to the long conducting wires not by electrostatic induction, as in Hertz's experiments, but by electro-dynamic induction. These conducting wires form, in fact, a closed circuit, part of which is brought near the circular wire of the exciter.

The modifications made in the resonator merit even more attention, since we know from the experiments of MM. Sarasin and De la Rive that it only depends upon the resonator what wave-length is observed. With the resonators hitherto employed it was impossible to verify Thomson's formula. The extreme capacities being very small the length of half the wave was in all cases a little longer than the length of the wire; with these capacities at zero there would be a node at either end. The measurement of the wave-length could not, therefore, tell us anything as to the propriety of employing the formula. M. Blondlot's resonator consists of a condenser of large capacity, the coatings of which are united by a relatively short wire. Owing to this arrangement we need not trouble about displacement currents, which are localised almost entirely in the excessively small thickness of the insulating plate.

The wave-length is measured directly, and the same with the capacity of the resonator, which we can determine experimentally by the classic method of Maxwell. The self-induction, on the contrary, can only be determined by calculation, which is legitimate if we assume on the one hand that Neumann's formulæ are applicable to such rapidly alternating currents, and, on the other, that the currents flow through the entire wire. This last condition is certainly not fulfilled in the case of ordinary resonators, but it is allowable to hope that it is fulfilled sufficiently well in the case of the new apparatus, where the extreme capacities are large.

M. Blondlot having varied the capacity and self-induction in the proportion of 1 to 4, finds, (i.) that the wave length is proportional to the square-root of the capacity, which verifies Sir W. Thomson's first law; (ii.) that the wave-length is proportional to the square-root of the coefficient of self-induction calculated as pointed out, so that everything happens as it would if the second law of Sir W. Thomson were correct, and the method of calculation were legitimate. It remains to complete the verification of the formula to measure the numerical coefficient which enters into it, and which ought to be equal to 2π, but there is no means of doing so. We might, perhaps, try to do so in the case of oscillations of a few thousands a second, and this should be a spur to investigators, but even then we should still have the right to ask if the coefficient did not vary when the period became a million times shorter.

It is none the less interesting to see what results are obtained when we give this coefficient the value attributed to it in Sir W. Thomson's theory; some consequences of which theory, as we have seen, have just received experimental corroboration. We can then calculate the speed of electro-dynamic induction. Applying this mode of calculation to his experiments, M. Blondlot has worked out fairly concordant numbers approximating the speed of light.

Other experiments of the learned physicist of Nancy deserve equal attention. They give us some information, in fact, as to the real nature of Hertzian oscillations, and appear to confirm the ideas which tend to prevail since the researches of MM. Sarasin and De la Rive. M. Blondlot has investigated, together with M. Dufour, the influence of a loop, and therefore of a dissymmetry introduced into the long-wire circuit. If the nodes and ventral segments pre-existed in the wires, and were only revealed by the resonator, as was thought some years ago, the presence of the loop would certainly displace them. It was not so; the position of the nodes and ventral segments was not affected. But when the length of the loop was varied it was ascertained that the intensity of the ventral segments varied periodically, and offered a series of maxima and minima. Things come therefore to pass as if two disturbances of very short duration left the exciter by the two wires, propagated themselves along these wires, and communicated to the resonator, by passing and repassing close to it, a certain number of impulses which put it into vibration, and the effects of which are additive or subtractive according as the interval of time which separates them is an even or uneven multiple of half the wave peculiar to the resonator. Another fact brought out by M. Blondlot's researches is the progressive diminution of these disturbances as they are propagated along the wires.

Such are the results of these researches; some may be regarded as definitely achieved, others remain to a certain extent hypothetical, since they are based partly on theoretical considerations, which are not yet completely verified. In any case they constitute as a whole one of the most important advances made in this branch of science since the experiments of MM. Sarasin and De la Rive. We are of opinion that there is reason to thank M. Blondlot for his communications, and to congratulate him for having thrown some light on one of the most important questions in natural philosophy.

CRYSTAL PALACE EXHIBITION.

The exhibit of the Brush Electrical Engineering Company, like those of several other important firms, loses a great deal of its effect by being divided into two parts. This scattering of the stands must add materially to the expense of the exhibitors; and the arrangement of the catalogue is, if possible, still more confused than that of the Exhibition. We have already described one or two features of the Brush Company's show; and we illustrate this week the improved method of mounting the coils of the Mordey alternator. In the early forms of this machine, the coils were bedded against the periphery of the ring which holds them in place. The cylindrical surface of the ring was easy enough to tool, but the mounting of the segments against it, and making a thoroughly stiff job of the whole, presented considerable difficul-

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ties. The work would be difficult enough if, instead of coils, solid metal castings had to be thus fitted; but, as has been found by all dynamo makers who have attempted to strike out new lines, the unmechanical properties of insulating materials call for exceptional constructive skill. In the new form of armature, which can be built without trouble to a very large diameter, the coils (see Fig. 1) are bolted flat against a web or internal flange. The bed being flat, not only is the mechanical work very much easier, but the segmental coils being free to slide in their own plane before the bolts are finally tightened, can be set up towards the centre, thus locking each other, owing to their wedge shape. The coils are mounted between substantial ebonite cheeks, and are held against the flange by three bolts in slightly oblong holes. Set screws, with tommy holes, are provided at the back of each coil, and these bear against the outer ring of the casting. The coils being screwed up finger-tight, these set screws are turned one by one, gradually forcing all the segments together. It will be remembered that the coils of the Ferranti dynamo are forced home under hydraulic pressure, until pins can be fitted into holes in the castings which carry them. These castings are mounted in the main hub of the armature, but depend for their lateral support on an insulating cement. The ease with which any coil of a Mordey alternator can be replaced and adjusted compares very favourably with the Ferranti machine, which it in some respects resembles. The nuts of the Mordey armature are locked by

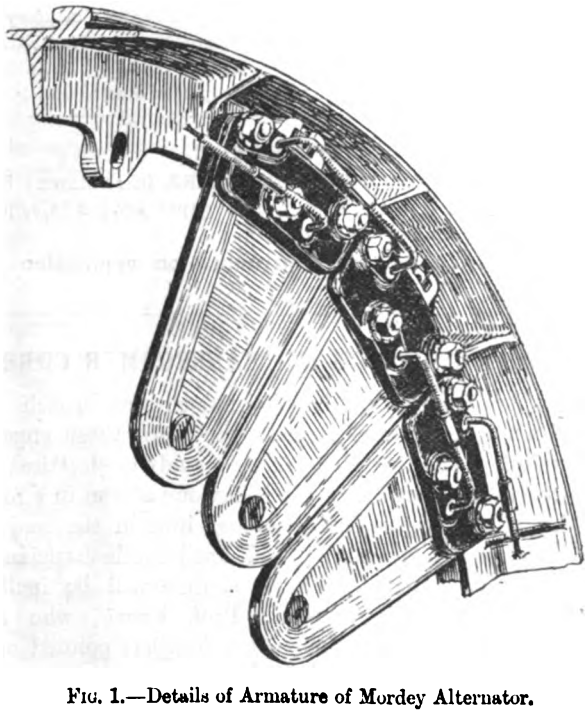

Fig. 1.—Details of Armature of Mordey Alternator.

means of sheet brass clips of a star shape, the arms being turned up against the sides of the nut.

While we have succeeded in finding little that is new, the search for something that has not already been described brings home very forcibly the very stable and developed state which has been reached by makers of electrical machinery and apparatus. But there is a very attractive department in which one might reasonably expect to find continual novelty, and that is in the fittings for electric light for domestic use. We have already expressed our inability to discover much that is artistic or original. Our attention has been specially invited to the stands of Messrs. Benham and Froud. The excellence of the productions of this firm is well enough known in other branches of decorative work, but in electric light fittings there is a little too much massive magnificence. Some of their fittings would do admirably for a palace or a big hotel. An Alfred Stevens' mantelpiece or the equipment of the chancel of a cathedral appears to be better understood by this firm than a simple bracket for a drawing-room. One of the best specimens of design is to be found in a dining-room shown by Messrs. Rashleigh Phipps and Dawson. It would be easy to pass through the room without noticing it, so poor is the general lighting; and the sight of a dining-room table with a gravelly grave in the middle of it, half filled with dank water plants, is enough to chill the most convivial gourmet. But it is original. The central pendant (Fig. 2) and the side brackets are designed by Mr. W. Bainbridge Reynolds, of 138, Lavender-hill, S.W., and symbolize the solar system, the centre light being the sun, and the brackets various planets. Illumination is the least that might be expected from the sun,

Fig. 2.

but the panels of the dome are filled with thick celluloid, to represent ivory, and the upper light is so swathed in silk that the really fine design of the ironwork, which is all forged and riveted, and partly polished, is nearly lost in the obscurity of a very gloomy ceiling. A general fault in electric light brackets is that, while very rarely objects of beauty in themselves, they are much too strong as mere supports for glow lamps. The principle of suitability in decorative art demands that the intention and object of a thing should be regarded. A bracket to carry a glow lamp, holder, and shade, even if designed with a factor of safety of 10, would be a rather fragile affair. The artist has in this case provided spheres to represent the planets, and these, at all events, give some appearance of a load for the very ornamental brackets to carry. The illustration of the centre piece is reproduced from a drawing by Mr. Reynolds. A little symbolism such as this is all very well; but Messrs. Rashleigh Phipps and Dawson, who might have displayed their goods in a more harmonious and artistic style, have so overdone the emblematic business that they have had to provide a small book to explain their devices.

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EDDY CURRENTS IN TRANSFORMER CORES.

The development of the alternate-current branch of electrical engineering has forced upon both those engaged in manufacture and those who make a study of electrical science a better acquaintance with the behaviour of iron in a magnetic field. MAXWELL practically ignored iron in the majority of his electromagnetic work; and until mathematicians have been provided with reliable data, they will be inclined to follow him in this respect. Prof. EWING, who has so exhaustively dealt with magnetisation, has pointed out that no subject has profited more by the beneficent reaction of practice upon science. While the last pages of his book were passing through the press Prof. J. J. THOMSON demonstrated that iron continued to be strongly susceptible to magnetisation, even under the extremely rapid oscillatory discharge of a Leyden jar. The combined efforts of two such men as Professors EWING and J. J. THOMSON cannot but produce valuable results. In the article which we published last week, the Professor of Experimental Physics alluded to some investigations on the absorption of energy by iron under Leyden jar discharges, and remarked that he understood from the Professor of Mechanism and Applied Mechanics that this question was of some interest to electrical engineers.

The results as to the influence of eddy currents just obtained by these Professors will probably cause general surprise. Anyone acquainted with the excessive heating which occurs in solid cores when placed in an alternating magnetic field will, however, readily agree that the magnetic force due to these currents must be quite comparable with that of the field which causes them, and that consequently they must have a considerable influence in

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modifying the distribution of the lines of force. One of the well-known experiments of Professor ELIHU THOMSON consisted in showing the violent repulsion existing between the eddy currents generated in solid copper bodies, and the pole of an adjacent electro-magnet fed with alternating currents. The specific resistance of iron is after all not so very large compared with copper; and as the magnitude of the eddy currents is inversely proportional to this quantity, the effect on solid pieces of iron must also be very striking. In fact, a solid piece of metal placed in an alternating magnetic field must be regarded as the short-circuited armature of a dynamo, and if the piece is of any appreciable size, a large amount of energy will be absorbed by the metal. The currents induced will be excessive, and the magnetic forces exerted by them in their immediate neighbourhood must have a most important effect on the lines of force. The tendency of the eddy currents is to neutralise the influence of the external magnetic forces, and when the medium in which the eddies circulate is of high conductivity, MAXWELL has shown that the demagnetising forces are of very nearly the same strength as the impressed magnetic forces; a similar equilibrium, as every one knows, takes place in the primary coil of a transformer where the back electromotive force generated is of practically the same magnitude as the voltage impressed on the primary.

The theory given by the authors does not take into consideration the loss of energy caused by hysteresis, since it was necessary in the calculations to assume constant permeability, and therefore that hysteresis did not exist. The effect of the screening action of the eddy currents must, however, have the result of increasing the waste due to this cause. The loss of energy per square centimetre is proportional, as Mr. STEINMETZ has shown, to the density of the magnetic lines when raised to the power 1·6; so that, if the lines of force are crowded towards certain parts of the core, the total loss is greater than if the lines are uniformly distributed.

But if the loss by hysteresis is increased by this screening action, the loss in eddy currents is diminished, for the crowding of the lines of force towards the surface of the iron must render them less effectual in generating currents in the core. Unless the core is finely laminated, the eddy current losses are so much more important than those caused by hysteresis that the effect of the screening must, on the whole, be to diminish the heating of the iron. With very thin plates, such as are used in transformers, this result may be reversed; but in such cases the phenomena observed by Profs. EWING and THOMSON are not very marked. The importance of the investigation is, indeed, chiefly due to the fact that the necessity of using very thin plates in transformers is brought out very clearly. When the core plates are laminated as much as is found necessary in practice in order to reduce the eddy current losses within reasonable limits, the screening effects described are almost negligible. For plates whose thickness lies between a quarter of a millimetre and half a millimetre, the density of the magnetic lines is, in fact, only about five per cent. greater near the surface than at the centre.

The investigation affords a rather good instance of the way in which practice and theory tend to diverge from one another. Only when, as in this case, the chief place is given to economic considerations, can theoretical work be expected to have a useful bearing. Engineers, by simply striving to get an efficient transformer, have found it needful to so laminate the core that the abnormal phenomena, disclosed by the Cambridge Professors, are comparatively unimportant. There must be a great number of such effects which, for the same reason, have as yet escaped notice.

ON MAGNETIC SCREENING, EDDY CURRENTS, AND HYSTERESIS, IN TRANSFORMER CORES.

BY PROF. EWING, M.A., F.R.S.

Electrical engineers are familiar with the direct effect of Foucault or eddy currents in causing dissipation of energy, and the consequent necessity of laminating iron which is to be subjected to rapidly alternating magnetic forces. But it appears to be less fully realised that eddy currents have another important effect, also of much practical interest in relation to transformers. I refer to the magnetic screening which they exert upon the interior of any plate or wire in the magnetic circuit. They prevent it from experiencing so wide a range of alternating magnetic force as the skin of the plate or wire experiences; and hence the greatest value of the mean magnetic induction in the core is less than it would be if the same exterior magnetic force were kept steadily applied. In consequence of this, it becomes necessary to apply a stronger external magnetic field in order to force the mean induction up to any assigned value—stronger, that is to say, than the field which would be sufficient if this screening did not occur. And hence the screening occasions two indirect losses: first, the loss due to hysteresis proper is augmented; and, second, the loss due to the magnetising current is also augmented.

When the plates of the core are comparatively thick, and especially when the frequency is comparatively high, the magnetic screening may become so influential that virtually only a small part of the thickness of the plate ever comes into play. The forced electro-magnetic wave which is set up, at the skin, by the externally applied alternating force, penetrates but a little way into the plate before its amplitude is reduced to a mere fraction of the skin value. The influence of magnetic screening turns out to be surprisingly great. For instance, when a plate of soft iron, two millimetres thick, is exposed (in the manner in which the plates in a transformer core are exposed) to an alternating magnetic force (of any moderate strength) with a frequency of 100, the portions of the metal which lie in the middle of the thickness experience only about one-eighth of the force which is applied to the skin. And even when the plate is only one millimetre thick, the force at the middle is but 52 per cent. of the force outside, under this same frequency of 100 periods per second.

The mathematical investigation which has been published by Prof. J. J. Thomson (*The Electrician*, April 8th, page 599) gives us the means of tracing, from point to point of the thickness of the plate, the value which is reached by the alternating magnetic force there in comparison with the value outside, so far as the reduction of the amplitude within the plate is due to eddy currents. No doubt there is a further reduction due to hysteresis; the wave as it penetrates loses energy through hysteresis as well as through generating eddy currents, but of this the theory does not take account, inasmuch as it assumes a constant value for the magnetic permeability. Hence the theory rather understates than overstates the extent of the magnetic screening. Prof. Thomson's equations also serve to determine the amplitude of the mean magnetisation taken across the plate, the rate of dissipation of energy by eddy currents, and the retardation of phase which the magnetisation suffers, on account of eddy currents, as it penetrates into the plate. From the values which the magnetic force reaches at various depths, we may further find the dissipation of energy due to hysteresis by taking advantage of the results of experiments made with slow cycles.* My object in this Paper is to follow up Prof. Thomson's investigation by applying to his equations some of the results of my own experiments, in order to examine the extent to which the screening due to eddy currents actually takes place, and to give numerical values of the losses that are due, on the one hand, to eddy currents, and, on the other, to hysteresis. The examples to be given relate to soft-iron plates, under the conditions in which they might be used in transformers, and may serve a useful purpose by indicating the extent to which it is desirable in practice to carry the lamination of the core.

* On the assumption, that is to say, that the work of magnetisation $\int H\,dI$ is the same in a fast cycle as in a slow one.

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In what follows

H_0 is the amplitude of the alternating magnetic force at the surface of the plate. It is supposed that this force varies in a simple harmonic fashion.

a is the half thickness of the plate in centimetres.

μ is the magnetic permeability of the material of the plate, which is assumed to be sensibly constant throughout the range of forces that are dealt with.

σ is the specific electrical resistance of the plate.

n is the number of periods (double alternations of the force) per second.

H_x is the greatest value which the alternating magnetic force reaches (in each period) at any point within the plate, the distance of the point from the middle of the thickness being x.

H_1 is the mean maximum value of the magnetic force, that is to say, it is the mean value of H_x from one side of the plate to the other.

H_2 is the maximum mean value of the magnetic force, that is to say, it is that value of (uniform) magnetic force which would cause the whole magnetic induction in the plate to reach the same value as it does reach in each period at the instant when it is a maximum. H_2 is not identical in value with H_1, because of the difference in phase at different depths.

E is the work (in ergs) wasted in eddy currents per second per cubic centimetre of the iron.

For brevity m is used to denote the quantity $2\pi\sqrt{\frac{\mu n}{\sigma}}$.

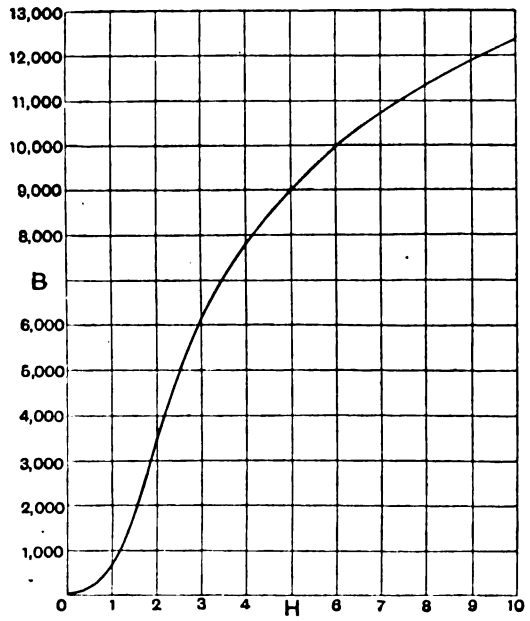

FIG. 1.—Curve of magnetisation of sheet iron.

Prof. Thomson's expression for the amplitude which the alternating force has at any point within the plate at a distance x from the middle of the thickness is

$$H_x = H_0 \left(\frac{\epsilon^{2mx} + \epsilon^{-2mx} + 2\cos 2mx}{\epsilon^{2ma} + \epsilon^{-2ma} + 2\cos 2ma} \right)^{\frac{1}{2}},$$

which may also be written

$$H_x = H_0 \left(\frac{\cosh 2mx + \cos 2mx}{\cosh 2ma + \cos 2ma} \right)^{\frac{1}{2}}.$$

The last form is handier when a table of hyperbolic cosines is available.* Similarly, the work spent on eddy currents is

$$\frac{H_0^2 m\sigma}{16\pi^2} \left(\frac{\sinh 2ma - \sin 2ma}{\cosh 2ma + \cos 2ma} \right)$$

per unit area of the plate, and hence

$$E = H_0^2 \frac{m\sigma}{32\pi^2 a} \frac{(\sinh 2ma - \sin 2ma)}{(\cosh 2ma + \cos 2ma)},$$

and

$$H_2 = \frac{H_0}{ma\sqrt{2}} \left(\frac{\cosh 2ma - \cos 2ma}{\cosh 2ma + \cos 2ma} \right)^{\frac{1}{2}}.$$

In applying these expressions to the sheet iron core of a transformer, we may take σ to be 10,000 and μ to be 2,000. In justification of this value for μ reference may be made to Fig. 1, which gives the results of a recent test I have made of sheet iron: from that it will be seen that throughout the range of magnetisation usual in transformers, say from $B = 8{,}000$ down to 4,000 or less, the permeability is fairly represented by 2,000. We must assume some particular frequency, and I have taken 100.

Substituting these numbers, we have

$$m = 2\pi\sqrt{\frac{2{,}000 \times 100}{10{,}000}} = 28{\cdot}1$$

Take now the case of a plate 1 millimetre thick. Here $2ma = 2{\cdot}81$. The value of H at the middle of the thickness ($x = 0$) is

$$H_0\sqrt{\frac{2}{7{\cdot}389}} = H_0 \times 0{\cdot}520;$$

and for other value of $\frac{x}{a}$, namely,

	0·2	0·4	0·5	0·6	0·7	0·8	0·9
$\frac{H_x}{H_0}$ =	0·521	0·538	0·561	0·601	0·664	0·750	0·861

The variation of H_x across the plate is shown graphically (by the curve marked "1mm.") in Fig. 2. The mean height of this

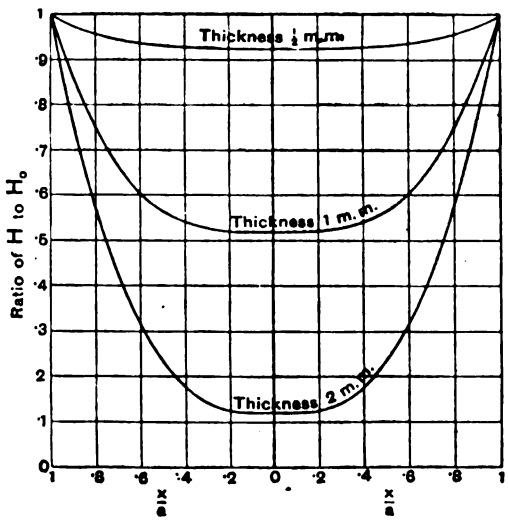

FIG. 2.—Distribution of magnetic force across iron plates of various thicknesses, when the frequency of alternation is 100.

curve is found to be 0·629 of the height at the ends, that is to say, at the surface of the plate. In other words,

$$H_1 = H_0 \times 0{\cdot}629.$$

The value of H_2 is directly calculated from the expression given above, which (since $\frac{1}{m\sqrt{2}} = 0{\cdot}02516$) may be written,

$$H_2 = H_0 \frac{0{\cdot}02516}{a} \left(\frac{\cosh 2ma - \cos 2ma}{\cosh 2ma + \cos 2ma} \right)^{\frac{1}{2}}$$

When the thickness is 1mm. this gives,

$$H_2 = H_0 \times 0{\cdot}564,$$

and this is the effective magnetic force which is to be considered in reckoning the number of lines of induction which suffer reversal at each alternation. This effective induction is of course μH_2.

* I have found Mr. Blakesley's tables, published by the Physical Society, a most useful labour-saving appliance in this connection.

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To find the waste by eddy currents we have $\frac{m\sigma}{16\pi^2} = 1780$, and when the thickness is 1mm.,

$$E = H_0^2 \times \frac{1780}{0{\cdot}1} \times 1{\cdot}076 = 19140\, H_0^2$$

Similar calculations for plates of other thicknesses give results which are summarised in the table below :—

Thickness of plate in millimetres.	Ratio of H at middle to H_0 (at surface).	Ratio of H_1 to H_0.	Ratio of H_2 to H_0.	$\frac{E}{H_0^2}$.
2	0·120	0·342	0·250	8885
1·5	0·245	0·42	0·341	12370
1	0·520	0·629	0·564	19140
0·75	0·739	0·82	0·793	20290
0·5	0 925	0·940	0·932	14220
0·25	0 995	0·996	0·996	4080

It may be useful to add figures and curves showing the variation of magnetic force across the thickness of the plate in the case both of comparatively thick and thin plates. Figures for the plate, 1mm. thick, have been given above.

For plates 2mm. and ½mm. thick respectively we have

	Values of H/H_0					
	$x/a = 0$,	0·2,	0·4,	0·6,	0·8,	1·0
Thickness 2mm.	0·120,	0·125,	0·173,	0·316,	0·580,	1·00
Thickness ½mm.	0·925,	0·925,	0·927,	0·935,	0·956,	1·00

The curves of Fig. 2 show the distribution in these two cases as well as in a plate 1mm. thick. It is interesting to notice how, with the assumed frequency, a great part of the interior of the 2mm. plate almost escapes magnetisation. On the other hand, the ½mm. plate is magnetised with a fair degree of uniformity throughout its whole thickness.

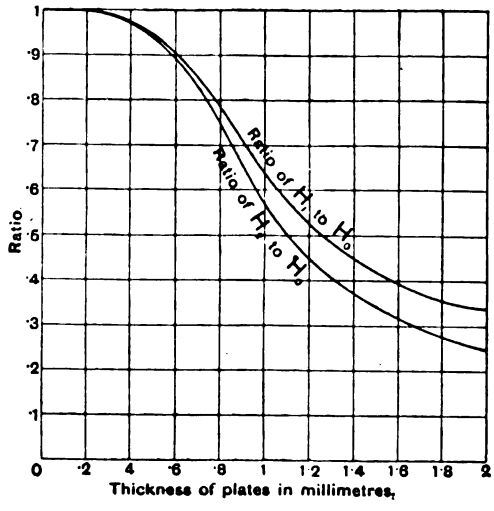

Fig. 3.—Magnetisation of plates of various thicknesses by alternating forces.

Fig. 3 gives values of the mean maximum amplitude H_1 and the maximum mean amplitude H_2 for plates of various thicknesses.

A convenient way of expressing these results as to magnetic screening is to give what I shall call the "equivalent depth of unform magnetisation." That is to say, the depth of an imaginary skin, which if magnetised uniformly with the full value of H_0 would contain the same total number of lines of force as the actual plate, with its varying distribution, does contain at that instant of each period in which the number is a maximum. The equivalent depth of uniform magnetisation on each side of the plate is equal to the maximum number of lines on either half of the plate divided by H_0.

Denoting it by b we have

$$b = \frac{a H_2}{H_0};$$

or, directly,

$$b = \frac{1}{m\sqrt{2}}\left(\frac{\cosh 2ma - \cos 2ma}{\cosh 2ma + \cos 2ma}\right)^{\frac{1}{2}}$$

The values of this quantity for plates of different thicknesses are stated below.

Thickness of plate in millimetres.	Equivalent depth of uniform magnetisation on each side (frequency 100).
	Millimetres.
Infinite.	0·252
2	0·250
1·5	0·256
1	0·282
0·75	0·285
0·5	0·233
0·25	0·1245

It will be seen from these figures that when alternating magnetic forces are applied to thick iron plates with a frequency of 100 the total magnetisation is substantially the same as if the plate consisted of two skins, each one quarter of a millimetre thick, with an empty space between. It is only when we make the total thickness less than the sum of two such skins that any very marked falling off begins to be seen in the total quantity of magnetisation in the plate.

Turning now to the losses by eddy currents and by hysteresis, we have seen how E, the loss by eddy currents, is calculated, and values of $\frac{E}{H_0^2}$ have been given in the table, for various thicknesses of plates, the frequency being 100. For most purposes what we chiefly wish to know is how E depends on the thickness of the plate, not under constant value of H_0, but when the mean magnetisation is forced up in the thick plates to the same value as it is in the thin plates. In other words, in comparing values of $\frac{E}{H_0^2}$ for different plates we are to take, for each thickness, that value of H_0 which is required to make H_2 the same in all, in order that the effective magnetisation may be the same in all.

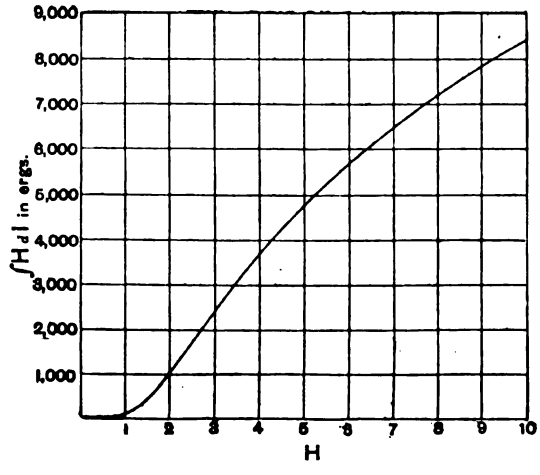

Fig. 4.—Loss due to hysteresis, per cycle, for various values of H, in the sheet iron of Fig. 1.

For example, let it be supposed that we are to work with a *mean* amplitude of induction B of 4,000. In plates which are indefinitely thin, this would require H_0 to be 2 (since $\mu = 2{,}000$). To force the same mean induction through thicker plates, H_0 has to be increased in the ratio $\frac{H_0}{H_2}$. Thus in plates ¼mm. thick, H_0 would have to be only very slightly greater, namely 2·01 ; in plates ½mm. thick it would have to be 2·15, in plates 1 mm. thick 3·55, and in plates 2 mm. thick it would have to be 8 (if the permeability could be still treated as nearly constant at so high a value of H).

The hysteresis loss depends upon the mean amplitude of magnetic force, which we have denoted by H_1. I find by recent experiments in which sheet iron cores were carried through slow cycles of magnetisation, that a very simple empirical formula serves well to express the relation of hysteresis loss per cycle, or $\int H\,dI$, to the amplitude of the magnetic force, throughout the range of induction which is common in transformers. Fig. 4 shows what appears to be a representative

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case, it relates to the same sheet iron as fig. 1. From $B = 2{,}000$ or even less, up to 8,000 the curve of $\int H\,dI$ and H is very nearly a straight line (not passing through the origin); and within these limits the formula

$$\int H\,dI = 1340\,H - 1610$$

seems very well to express the work done per cycle in ergs per cubic cm. By using H_1, which is the mean amplitude of H across the plate, we may at once apply this formula to find the hysteresis loss in plates of various thicknesses. For instance, in a plate 1 mm. thick, if the induction is to be 4,000, we have seen that (for a frequency of 100) H_0 must be 3·55. Hence H_1, which by the table is equal to 0·629 H_0, is 2·23, and the value of $\int H\,dI$ for a cycle is $1340 \times 2{\cdot}23 - 1610$, or 1380 ergs. Thus the hysteresis loss per cubic cm. per second is 138,000 ergs. We have already seen that the eddy-current loss per cubic cm. per second in a plate of this thickness is $19{,}140 \times H_0^2$ or 241,200 ergs. Thus in this case the loss due directly to eddy-currents is larger than that due to hysteresis.

Proceeding in this way I have calculated the following figures for the losses due to eddy currents and to hysteresis in plates of various thicknesses, when the induction has certain assigned values. All these calculations, it is to be remembered, relate to an assumed frequency of 100.

Plates ¼mm. thick.

Mean amplitude of induction B.	Eddy current loss per cub. cm. per second. Ergs.	Hysteresis loss per cub. cm. per second. Ergs.	Total loss per cub. cm. per second. Ergs.
4,000	16,500	107,000	123,500
6,000	37,000	241,000	278,000
8,000	66,000	375,000	441,000

Plates ½mm. thick.

Mean amplitude of induction B.	Eddy current loss per cub. cm. per second. Ergs.	Hysteresis loss per cub. cm. per second. Ergs.	Total loss per cub. cm. per second. Ergs.
4,000	66,000	110,000	176,000
6,000	147,000	245,000	392,000
8,000	262,000	379,000	641,000

Plates of various thicknesses, when B = 4,000.

Thickness (millimetres)	H_0	H_1	Eddy current loss per cub. cm. per second. Ergs.	Hysteresis loss per cub. cm. per second. Ergs.	Total loss per cub. cm. per second. Ergs.
2	8	2·74	569,000	206,000	775,000
1·5	5·87	2·46	427,000	169,000	596,000
1	3·55	2·23	241,000	138,000	379,000
0·5	2·15	2·02	66,000	110,000	176,000
0·25	2·01	2·00	16,500	107,000	123,500

These last results are also shown in Fig. 5, where curves are drawn to exhibit the two kinds of loss, and also the sum of them, in relation to the thickness of the plates. It is interesting to notice how, with the assumed frequency of 100, any thickness greater than ¼mm. causes the losses by eddy currents to become important. So long as the thickness does not exceed ¼mm. nearly the whole loss is due to hysteresis. But even when the thickness is no more than half a millimetre, the eddy current loss forms more than one-third of the whole loss; and in thick plates it greatly exceeds the other. Further it is to be noticed how the loss by hysteresis increases slowly as the thickness of the plate is increased. This is an indirect effect of magnetic screening, alluded to at the beginning of this Paper. Though the average amplitude of magnetisation is kept constant the hysteresis loss is not constant, it is increased in consequence of the inequality of the magnetisation.

As to the practical question of the degree to which lamination ought to be carried in the magnetic circuit of a transformer, two things are to be considered: first, what thinness will suffice to avoid serious magnetic screening; and, next, what thinness will suffice to avoid serious eddy current losses. From the number and figures which have been given it will be clear

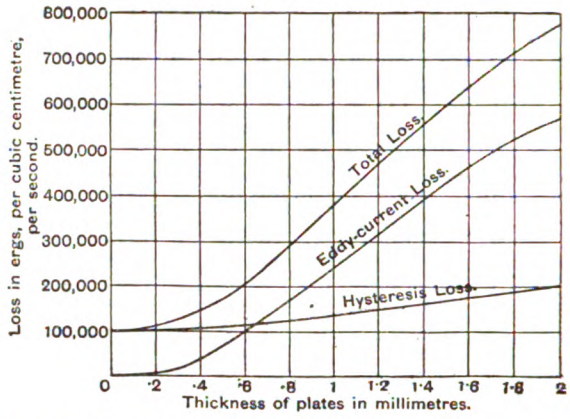

Fig. 5.—Losses due to eddy currents and hysteresis in sheet iron plates, when B = 4,000, and frequency = 100.

that the magnetic screening ceases to be serious when the thickness is reduced to ½mm., and, so far as uniformity of magnetisation is concerned, there is little advantage in laminating further than that. But when we come to consider eddy currents we see that a greater amount of lamination is desirable to prevent the eddies from causing a serious addition to the loss which hysteresis makes inevitable. Fig. 5 shows that the thickness should be reduced to something more like ¼mm. On the other hand, to reduce the thickness to less than ¼mm. would be useless (unless the frequency were very considerably increased) and worse than useless, inasmuch as the non-magnetic space in the core would be needlessly increased.

These conclusions justify what I understand to be the present practice of good makers of transformers in using plates the thickness of which is only about 0·014in. or 0·35mm.

NOTES ON SUBMARINE CABLE WORK.

BY H. D. WILKINSON.

(*Continued from page 566.*)

7. Picking Up.—The ship now starts picking up cable towards the fault, the main engines being kept moving easy ahead in order to keep the ship's head to the cable and relieve the strain on the picking-up engine. The cable comes in at the rate of about one or two miles an hour in deep water, a six-foot winding-drum being slowly driven at about 10 revolutions per minute. The steam engine used for driving the picking-up gear runs at about 150 revolutions per minute, the power being transmitted from the engine to the drum shaft through spur gear on two or more intermediate shafts, by means of which the speed is reduced. The length of cable hauled inboard can be ascertained at any moment from the indications of a revolution counter or rotometer, which records the total number of revolutions made by the winding-in drum. One form of rotometer, contained in a brass box about 1½in. square by 6in. long, consists of a set of discs, each with ten figures on the rim, which show themselves in succession through holes in the cover of the instrument as the impulses are given. By a simple gear between the discs they are made to indicate units, tens, hundreds, thousands, and tens of thousands of revolutions. An impulse is given every revolution by the lever C (Fig. 25) jointed to the lever L, which is lifted for a short period of every revolution by the pin *p* projecting from the side of one of the wheels on the winding-drum shaft. The rotometer box is fixed in any convenient position for reading as at S, supported by the bracket M. A note is taken of the figures as they stand before the cable end first winds round the drum; and the difference between this number and that observed at any

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subsequent period is the number of revolutions made. This multiplied by the circumference of the drum in feet and divided by 6,087 gives the length in knots of cable picked up, and is entered in the Electrician's log in knots and fractions of a knot to three places of decimals.

After the cable passes the picking-up drum it is coiled into one of the tanks on board. If the cable has to be coiled in the fore tank it is simply passed from the picking-up drum direct through a ring in the cable hatch, and down into the tank; but if to go in any tank aft, a number of V sheaves are placed in convenient positions along the deck as guides, over which the cable rides to the required tank. The ring or dead-eye, which is fixed to timbers over the centre of each hatchway, is placed horizontally, so that the cable threads straight down through it into the centre of the tank, the edges of the ring being bell-mouthed out above and below for the cable to run smoothly through.

Some ships carry two tanks forward of the engine-room and one aft, while others carry four, the tanks varying in size according to the tonnage of the ship. The average gross tonnage of cable-repairing ships for deep-sea work is from 1,000 to 1,500 tons, but many are smaller than this. There are about twelve cable ships in different parts of the world, whose respective gross tonnage varies from 300 to 1,000 tons. The very large vessels of gross tonnage ranging from 2,000 to 5,000 tons are owned by cable-manufacturing companies, the great advantage of their size being that in laying new cables, the capacity of the tanks is sufficient to permit of the ship taking

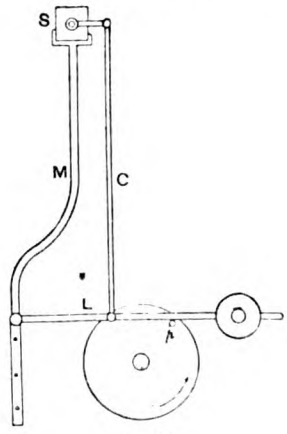

Fig. 25.

out from 1,000 to 2,000 miles of cable in one trip. Considerable space and accommodation on board is also required for the cable hut material, stores, testing instruments, and staff destined for shore work while the ship is laying cable. Of these large vessels there are five, namely, the "Silvertown," of 4,935 tons (one of the four ships owned by the India-Rubber, Gutta Percha and Telegraph Works Company), the "Faraday," of 4,916 tons, owned by Messrs. Siemens Brothers and Co., and the "Scotia," of 4,667 tons, the "Seine," of 3,553 tons, and the "Calabria," of 3,321 tons, owned by the Telegraph Construction and Maintenance Company.

As mentioned above, steamers for deep-sea work designed for repairing purposes only, and therefore not required to carry great lengths of cable, have, on the average, a gross tonnage somewhere between 1,000 and 1,500 tons. Such vessels are usually fitted with four tanks, which are numbered consecutively, commencing from the one nearest the bows. In several of these ships, No. 1 tank is about 14ft. diameter, No. 2, 25ft., and Nos. 3 and 4 about 16ft. or 17ft. The two first are built on the water-ballast tanks forward of the engine room; the largest, No. 2, being about 12ft. deep, and the top reaching very nearly to the level of the main deck. The tank is entered by going down to the lower deck, climbing up over the edge of the tank, and then descending by the foot pockets. If the tank contains many lengths of cable there will be a number of ends sticking out above the top, and lashed to the side of the tank in a convenient position for connecting on leads to the testing room. Both ends of each length of cable are secured in this way, so that in testing any given length both ends may be used, or one end freed or earthed, the earth used being the outside sheathing wires of the cable. The ends of each length are labelled, and marked with the type of cable and the length coiled in.

Cable is always coiled from the outside of a tank inwards, and as it cannot be coiled right to the very centre of the tank, a hollow cone, about 6ft. diameter at the bottom, and tapering up to 3ft. at the top, is placed in the centre of each tank. These serve to keep in position the several turns of cable composing each flake, and are otherwise put to use in holding fresh water.

Fig. 26.

Inside the tank, while cable is coming on board, a number of men, varying from six to twelve according to the size of the tank, are employed at coiling. One man runs round and round the tank, keeping up his pace at the rate the cable comes in, and pushing it outwards towards the remainder of the men, who are stationed round the tank at equal distances. As the cable passes each man he seizes it and lays it down close to the last turn, so that the coils

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are kept regular, and kinks avoided. Native seamen, who are chiefly employed as crew on cable ships abroad, do this work very well, singing or yelling in their own way while doing it, their voices reverberating again and again in the large hollow tanks, and producing a strange medley of sound.

While picking up cable, especially if it has been somewhat buried, and not touched for a number of years, it comes up covered in many places with beautiful deep-sea growths, the roots having got a very firm all-round grip of the cable. The appearance of these as the cable emerges from the water is that of ferns of delicate tracery spread out like fans, and shining with colour, either green, brown, or red. As the cable passes over the bow sheaves most of these are crushed out of shape, but some pass unhurt. The writer collected some specimens of these growths while engaged on the repair of the cable between Singapore and Saigon some years ago, and has endeavoured to give some idea of their formation by the sketches in Fig. 26. Two of these (*Gorgonidæ Menacella Sp.* and *Plexaura Flabellum*) measure 19in. × 15in., and are fan-shaped; the other (*Gorgonidæ Engorgia Nobilis*) is a smaller specimen of a deep red colour. In some instances these are covered over by Polyzoa. The cable in question had not been touched for several years, and was deeply imbedded in mud at the time of picking up.

(To be continued.)

THE CHEMICAL AND PHYSICAL PROPERTIES OF ROSIN OIL.

Until recently it was generally believed that the use of rosin oil was almost entirely confined to the manufacture of printing inks and cart grease, and the adulteration of other and more expensive oils. Although large quantities of it were manufactured, but little found its way into the retail market, at least under its own name. There is now, however, some probability of an increased consumption taking place owing to the rediscovery of its properties as an insulator; and it will not, therefore, be out of place to say something concerning its nature and properties, if only to dispel the vague atmosphere with which the subject has been surrounded, and to show how completely any dogmatic statements that have been made, or may be made, must be modified by a consideration of the quality of the oil referred to.

In the first place, rosin oil is so called because it is the heavier part of the products of the destructive distillation of rosin, which, in its turn, is the residue left by distilling crude turpentine, spirits of turpentine being the volatile portion. The ordinary vitreous body, varying in colour from light yellow to almost black, known as rosin, consists of a mixture of abietic acid and abietic anhydride, together with a small quantity of sylvic acid. When distilled, these bodies are broken up, yielding a mixture of hydrocarbons, accompanied by a larger or smaller proportion of unchanged rosin acids and anhydrides. The relative amount of these constituents is determined by the design of the stills and the manner in which the distillation is conducted. The more carefully prepared and refined the oil is the lower is the proportion of rosin acids, and in the laboratory rosin oil may be obtained with but a few per cent. of substances other than hydro-carbons. The specific gravity of rosin oil of commercial quality may vary from 0·98 to 1·10, while its power of rotating a beam of polarised light is similarly variable, being generally dextro-rotatory, but sometimes lævo rotatory, or nearly absent. These facts are sufficient to indicate the variable character of commercial rosin oil, and the futility of discussing its electrical properties without defining the character of the sample used is tolerably apparent. In the various communications which have lately been made concerning rosin oil insulation, this necessity has not been sufficiently kept in sight. The only satisfactory method of settling once for all the kind of oil best fitted for this purpose would be to examine the insulating capabilities of numerous samples, and simultaneously determine their composition by analysis. If this were done and it were ultimately found that rosin oil could be as advantageously used as some of its advocates appear to think, there would be afterwards no difficulty in obtaining supplies of precisely the same quality as those which had been found efficient. The maker would be given a definite standard to work to, and could, by the aid of his chemist, match that standard as nearly as would be necessary.

In dealing with rosin oil, one of the most noteworthy qualities that are apparent on inspection is its great viscidity. It is to this, and to its immiscibility with water, that its applicability for the purposes of insulation is chiefly due. It is, therefore, plain that in addition to a purely chemical examination, the determination of the important physical property of viscosity would have to be undertaken. Thanks to the advances that have been made in the methods of examining lubricating oils, there is no difficulty in effecting this. Besides determining the viscosity at ordinary temperatures, it would be very desirable to do so at higher temperatures, as it by no means follows that oils of the same viscosity at any given temperature have the same coefficient of decrease as the temperature is raised. There is a further point which seems to have been also overlooked. Rosin oil when exposed to air undergoes change. How noteworthy that change may be has been opportunely illustrated by some figures given in a Paper by Mr. F. H. Leeds, which was recently read before the Society of Chemical Industry. The results of three of the samples examined are given below:—

No. of sample.	Original oil.		Oil after exposure to air.	
	Rosin acids.	Hydrocarbons.	Rosin acids.	Hydrocarbons.
A	31·07	68·93	24·90	75·10
B	22·20	77·80	16·09	83·91
C	9·72	90·28	4·29	95·79

The results show that a considerable amount of alteration has taken place. There is an apparent decrease under the column headed rosin acids (which strictly means total saponifiable matter, including probably anhydrides and esters), and an increase under the head of hydrocarbons. It is unlikely, on purely chemical grounds, that a conversion of the former into the latter takes place. Probably the explanation of the change is to be sought in the volatalisation of the lighter acid constituents, and the consequent enrichment of the mass in heavy non-volatile hydrocarbons. In the Paper in which these results appear, other differences are recorded and discussed, but, being at present still unsettled, do not immediately concern us. One deduction is, however, plain, namely, that an oil may undergo profound alteration by exposure, and may well alter in character to such an extent as to become more or less useful in tangible degree. It can, therefore, never be safe to assume that, because a specimen of oil has at one time given certain results, it will necessarily possess identical properties after the lapse of time, particularly if the conditions under which it has been kept have involved its exposure to the atmosphere. This again opens up a field for investigation, in that not only do all kinds of rosin oil change, but that the tendency of oils of different qualities to alter by exposure varies greatly. It is probable that samples consisting almost wholly of hydrocarbons would prove the most resistant, and, if found to be also high in insulating power, would be preferable on that account. Direct experiment is, however, much needed.

ELECTROPLATING WITH SILVER ALLOYS.

Some time ago we published a Note upon the method of electroplating called "Arcas Plating." The earlier samples of this product, to which, being then a secret, we did not give much attention, consisted of an alloy of zinc and silver, containing about 10 per cent. of the former metal, and the property which distinguished it from ordinary plating was its resistance to those tarnishing influences which affect silver. An alteration in the method has been lately made, and the alloy now deposited is one of cadmium and silver, or of zinc, cadmium and silver. The percentage of cadmium used is from 25 to 35 per cent., although for common work a much larger proportion of the cheaper metal may be employed. The bath is made by dissolving cadmium cyanide in a solution of potassium cyanide, and adding a small quantity of the double cyanide of potassium and silver. The anode consists of an alloy of cadmium and silver of about the same composition as

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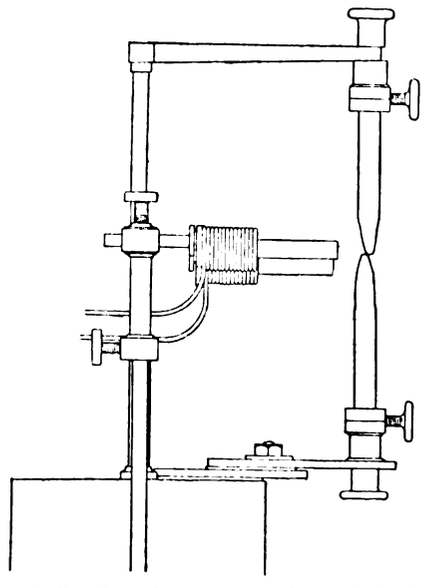
the deposit required. The bath is worked cold, and the electrodes are kept in motion in order to prevent the formation of layers in solution of different densities. For this purpose the plates are carried on a frame, to which motion is communicated from a shaft running parallel to the end of the bath, by means of a rod and eccentric, and at the same time a vertical movement is obtained by causing the frame to ride up short inclined planes placed at the side of the bath. The alloy can be deposited on such metals as form a suitable substratum for silver plating, either direct upon white metal alloys, or on a previously-coppered surface in the case of iron. A weight of 1oz. to the square foot gives a good coating, and, like the original alloy there is said to be less tendency to tarnish than when silver alone is used. Greater current density can also be adopted, so that a given tank will turn out about twice as much work as when silver plating is being done. A curious phenomenon has been noticed in rolling the metal for anodes. When the proportion for cadmium slightly exceeds 35 per cent., the plate shows a tendency to split longitudinally into strips of triangular section, the bases and apices of which alternate on each side of the plate. No explanation, as far as we are aware, has been advanced to account for this effect, which certainly merits investigation. The process as a whole is chiefly interesting from the fact that it adds another to the scanty list of those in which an alloy is successfully deposited. It may be that in time alloys will hold as useful a position in commercial electrolysis as they already do in other industrial arts.

THE PECKHAM ARC REGULATOR.

For a year and more past, says Mr. W. C. Peckham, in the *Electrical World*, I have been using upon the arc lamp in my lantern a device to hold the arc in a fixed position in the front of the carbons, which works very successfully.



Peckham's Regulator for use on Arc Lamps in Projectors.

The device consists of an electro-magnet, wound with a few turns of No. 12 insulated copper wire in series with the lamp. The cores project (see Fig.) about 1½in. beyond the coils, so that these are set back beyond the great heat of the arc, which would destroy their insulation. An asbestos covering would still further protect them, if necessary. The wires are connected so that both poles drive the arc toward the farther, or front, side of the carbons. Wherever it is desirable to hold the arc in a definite position this regulator has value. It can easily be attached to any form of lamp, focussing, or search light.

The illustration shows the lamp with regulator in position. It is secured in the same plane with the focus of the condenser and the axis of the lenses. The regulator is attached to the base of the lamp, and does not move when the carbons are adjusted to focus, as they burn down.

ON THE UTILISATION OF THE WASTE FORCES OF NATURE.*

BY W. H. PREECE, F.R.S.

The sun is the *fons et origo* of all the available energy upon the surface of our earth. Countless ages ago its warm and vivifying rays promoted the growth of plants and ferns and trees, which, falling where they grew, formed those great beds of coal now being brought to the surface, and which, combining with the oxygen of the air, provide us with heat and power to supply our wants, to maintain our manufactures, and to expedite our locomotion. These same rays are now in a similar way hastening the growth of trees and making wood, the difference between wood and coal as fuel being only age. They are now also furthering the annual growth of grasses, corn, fruits and vegetables to become food for beast and for man, and to supply them with fuel to maintain their life, their strength, and their capacity for work. The same rays playing on the surface of the waters promote the evaporation of the liquid into gas, which, mixing invisibly with the air, gives evidence of its presence when the lowering of temperature causes its condensation into the floating clouds and its ultimate return into the waters in the form of the gentle rain, the rippling brook, the roaring torrent, or the flowing river. The sun's rays, again, produce that variation of temperature in our atmosphere leading to currents of air which sometimes fan our faces with cool and refreshing breezes, and at other times rage and roar with the relentless fury of a tornado. The sun, together with the moon, so attracts the mobile waters of the ocean that it produces great periodic waves and currents known as the tide, which ebbs and flows with such uniformity and regularity that we can calculate the rise and fall of the water at any particular spot, and its rate of flow, not only at the present day, but for any future time, provided the geographical conformation of the land and the bottom of the sea remain unaltered.

Coal and oil pent up in the bowels of the earth and water accumulated in the higher levels of the land are our great stores of energy, available for the wants and purposes of man. The wind, the running streams, and the flowing tide are the passing forms of energy which are available for our present use, while food is the particular form of fuel which maintains life and provides the means of doing work. These are all natural sources of energy; while gunpowder, gas, compressed air, steam, chemical affinity, &c., are artificial sources which the ingenuity of man has fashioned for his use.

In that interesting work of Smiles, "The Story of the Life of George Stephenson," we read: "One Sunday, when the party had just returned from church, they were standing together on the terrace near the Hall, and observed in the distance a railway train flashing along, throwing behind it a long line of white steam. 'Now, Buckland,' said Mr. Stephenson, 'I have a poser for you; can you tell me what is the power that is driving that train?' 'Well,' said the other, 'I suppose it is one of your big engines.' 'But what drives the engine?' 'Oh, very likely a canny Newcastle driver.' 'What do you say to the light of the sun?' 'How can that be?' asked the doctor. 'It is nothing else,' said the engineer; 'it is light bottled up in the earth for tens of thousands of years—light, absorbed by plants and vegetables, being necessary for the condensation of carbon during the process of their growth, if it be not carbon in another form; and now, after being buried in the earth for long ages in fields of coal, that latent light is again brought forth and liberated, made to work, as in that locomotive, for great human purposes.' The idea was certainly a most striking and original one; like a flash of light it illuminated, in an instant, an entire field of science."

I have used the words *work*, *energy* and *power*. *Work* is the effort exerted when we overcome resistance. When we walk upstairs we overcome the resistance due to the attraction of the earth, and we raise our bodies to a higher level. Work is thus done by ourselves on ourselves. When a train is moved from Liverpool to Warrington the friction or resistance of the

* Read before the Liverpool Welsh National Society and the Liverpool Engineering Society, April 6th, 1892.

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rails is overcome as well as that due to gravity (for we go up hill). Work is thus done by the locomotive on the train of carriages. Force has been applied, resistance has been overcome through a certain distance; and this is the measure of work expended. But this capacity for doing work must exist in a dormant state both in our bodies and in the locomotive, and this is called *energy*, which is stored up in food and in fuel, energy being simply the capacity for doing work. While the work done or energy expended is measured by the distance through which resistance has been overcome and by the weight of the object moved, the *rate* at which the *energy* is expended or the amount of work done per minute or per second is the *power*. Power is, therefore, the rate of doing work. Watt called the work expended in one minute in raising 33,000lbs. (14¾ tons) one foot high a *horse power*, and this is the same as raising 550lbs. per second. A man can raise ½cwt. per foot per second for a short time. A horse dragging a cart of materials weighing one ton over a level road at a speed of four miles an hour exerts this power; and one of Mr. Webb's locomotives driving an express train over the London and North-Western Railway at sixty miles an hour may expend about 750 horse-power. Fourteen gallons of water falling four feet per second could perform about the same work as this typical. horse, and thus a horse-power becomes a very convenient, though rough and unscientific measure of the rate of expending energy.

Energy is expended when coal or wood is burnt, when water falls, when tides flow, when the winds blow, when food is digested; and the function of steam and gas-engines, of water-wheels and turbines, of windmills and of beasts of burden, is to transmit this energy to some spot where it can be utilised for the wants and purposes of man. But water is ever falling in the mountains of Wales, shining rivers flow on for ever and for ever, the tides ebb and flow daily in our straits and estuaries, the wanton winds expend their energies always over the surface of the land; and man neglects these stores of energy that Nature gives him at his very door.

Let us assume that we have at our command, at one spot, some source of energy, such as a steam-engine or a water-turbine, how can we transmit the power exerted to some other spot where it can be better utilised? Belts and shafts and ropes are at our command. A 4-in. rope, moving at a speed of 2,000ft. per minute, transmits 8 H.P. The valleys of Switzerland abound with such conveniences. We may even lead the water itself in pipes and channels, and in America they even distribute the live steam over considerable areas. Gas is a very convenient medium for the distribution of actual energy, and since the advent of the electric light its use for this purpose has been very largely encouraged. In the United States it is found in a natural state underground, and it is being conveyed to distances of even 100 miles.

Compressed air is a very convenient medium for the transmission of energy. It is largely used in mines. In London it is employed for the transmission of telegrams, and in Paris it is in successful work for postal work and for a large number of industrial pursuits. 10,000 H.P. can be transmitted 20 miles in a 30-in. pipe by air at 132·3lbs. pressure, with an efficiency of about 40 per cent., that is, about 60 per cent. of the original energy is wasted or lost in transit. The efficiency of a system is the ratio of the energy utilised to the energy expended. Thus to get 1,000 H.P. at the end of a pipe 20 miles long, we must expend 2,400 H.P. at the beginning.

The common way of transporting energy is by cart, or by train, or by ship. Thus coal and wood are carried anywhere, but at a price. This also means an efficiency for the cost to the consumer is much enhanced by the carriage of the material. Coal at the pit's mouth costs 6s., in Liverpool it may cost 18s. per ton; its efficiency is thus 33 per cent. In London we have been paying 30s. per ton; the efficiency is, therefore, only 20 per cent. There is another mode of transmitting energy, and that is by the electric current. It is not my intention to occupy your time with a description of a dynamo. It must be known to most of you; Electric Exhibitions have made us familiar with the principal industrial electrical apparatus. The dynamo is an instrument designed to convert the mechanical energy of motion into the form of energy called electrical. The answer to the question, "What is electricity?" is now, "Principally coal and sometimes water." Five pounds of coal consumed per hour in a furnaceflashes 50lbs. of water into steam. The steam in its re-conversion to water transfers its energy to a moving mass of machinery, a part of which consists of copper rods forming a portion of an electric circuit. These rods rotate in a magnetic field where work is done on them, and where, in consequence, the mechanical energy of motion is converted into the molecular energy of electricity. The 5lbs. of coal have produced 1⅓ H.P., or 1,000 watts in the circuit; in fact, a kilowatt is the scientific unit of power, and a kilowatt-hour is the Board of Trade unit of energy for the use of which the Electric Lighting Company of Liverpool is allowed to charge 8d. A watt is the energy expended by an ampere when driven by a volt. It is equivalent to nearly ¾ (actually 0·737) of a footpound. The ampere is the unit current, and the volt the unit electrical pressure. A 16-candle glow lamp requires 100 volts and 0·48 ampere to incandesce it into brilliance. It therefore absorbs 48 watts and consequently 1 c.p. is produced by 3 watts. Hence, a kilowatt-hour uniformly expended will give us 333 candles continuously, or it will maintain 21 such lamps alight. But this kilowatt of energy need not have given us light; it could have been converted into other forms of energy; it could be used for electro-metallurgical purposes; it could deposit copper; it could produce aluminium; it could break up salt solution into chlorine and caustic soda; it could silver our plate and gild our cups; it could be re-converted into mechanical energy by electric motors; and could again drive machinery, turning mangles, knife-cleaning machines and ventilators in our dwellings, sewing machines in our shops, blowing organs in our churches, driving tramcars on our streets and trains on our railways. Again, it could give us heat, warming our rooms, heating our irons, and, as we see every day in the Crystal Palace, boiling our water and cooking our food.

I am anxious to attract your attention especially to the facility which the electric current gives us to bring power to our doors and to enable us to facilitate home industries. The congregation of large bodies of males and females in magnificent buildings is a modern consequence of great industries dependent on the presence of great power and great steam-engines. A system of centralisation has followed, which is not always beneficial to healthy mental and corporeal growth. The electric current steps in to check this system. It enables us to apply in our own dwellings power from the smallest fraction of a horse-power to many hundred horse-powers.

Moving water as a source of power is already utilised to a very large extent. At Bushmills, near the Giant's Causeway in Ireland, there is a fall of 26ft., which, actuating turbines, produces currents of electricity that drive a railway from Portrush, a length of six miles. This line has been at work since 1883. Between Newry and Bessbrook, also in Ireland, there is another railway worked electrically, in the same way and of the same length. At Lynton, in Devonshire, and at Keswick, in Westmoreland, the fall of water is used for electrically lighting the two places; while at Tivoli, near Rome, 2,000 H.P. is going to be converted into electrical energy which will be transported 18 miles to Rome to light up 40,000 lamps. At Geneva the lake which merges there into the river Rhone flows through the town with considerable velocity, and more than 3,000 H.P. is there obtained, not only for electric lighting purposes, but to raise water to a height of over 400 feet, so as to distribute its energy over the whole town for the innumerable watch, musical box and other industrial purposes for which that town is so famous. At Schaffhausen (the famous falls of the Rhine) about 600 H.P. is converted into electrical energy, and is applied to the production of aluminium, and 700 H.P. for the transmission of power to a woollen spinning mill about half a mile away, the wires crossing the river. At the Skippers Creek Mountains, near Otago, in New Zealand, two 50 H.P. turbines generate electrical energy, which is transmitted three miles to work quartz stampers. At the Virginius mines in Colorado some unprofitable mines at a height of 12,700 feet have been made profitable by the utilisation of water at the foot of the mountain. Labour has also been reduced. Two pumps, a hoist, a blower, and two mills

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are worked by electric motors, 1,200 H.P. being available for transmission four miles up the mountain by current.

The economy of the transmission of energy by electricity is a question of pressure. The higher the voltage (pressure), the smaller the conductor needed, and the greater the distance to which it is possible to transmit the energy. It is difficult to obtain high voltages except through the aid of alternate currents and by means of induction apparatus which transform low to higher pressure. The apparatus for doing so is extremely simple and effective. The Ferranti apparatus in Deptford generates 10,000 volts directly by a dynamo which drives currents eight miles to London, and is there re-transformed down first to 2,400 and then to 100 volts for electric lighting purposes. At Lauffen, on the Neckar, a turbine worked by the falls there absorbing 300 H.P. with a head of 10ft. excited a dynamo to 50 volts and 4,000 amperes. These low-pressure currents passed through a transformer which raised the voltage to 16,000 volts. Three small bare overhead copper wires (No. 8 gauge), insulated on oil insulators, conveyed this energy to Frankfort, 108 miles away, where it was transformed down to 75 volts, and there used both for motor and for lighting purposes. The apparatus worked during the existence of the Frankfort Exhibition last year, and it is now employed in lighting electrically the town of Heilbronn, nine miles distant from the falls, but at a pressure of 5,000 volts. The peculiar feature of this Lauffen system is the use of three wires and three alternating currents, one in each wire, flowing at different phases, following each other like the relative motions of the three cranks of a three-cylinder steam-engine, or of a three-throw pump. This "Drehstrom" cures all the defects of alternating motors; it causes no disturbance to contiguous telephones and telegraphs; it is sparkless and safe, and the apparatus is remarkable for its simplicity. The system has been practically worked out by Tesla in the United States of America, and by Dobrovolski in Berlin. It solves the question of economically transmitting energy to great distances. Coal may be burnt at the pit's mouth, and 75 per cent. of its useful electrical energy delivered in London. The energy of the Swallow waterfall at Bettws-y-Coed may light up the streets of Liverpool. The foaming torrents of the Highlands can be made to drive the tramcars of Glasgow. It is proposed to transmit energy by this method from Niagara to Chicago next year—a distance of 500 miles—and this can certainly be done with a voltage of about 40,000 volts, and with an efficiency of about 60 per cent.: 5,000 H.P. generated at Niagara would deliver 3,000 H.P. at Chicago. The principal cost of the system lies in the construction and upkeep of the wires; the cost of the plant is small and the labour insignificant. It remains to be seen how the relative economy of coal carriage and energy transmission will affect this great industrial question. Anyway we may conclude that the experiment at Frankfort has practically solved the question of transmitting energy to a distance and of working motors by alternating currents.

How, then, are we to utilise the waste forces of Nature?

The sun's rays pouring on the desert of Sahara are generating the equivalent of millions of horse-power in the heat absorbed by that great sandy waste. Sunshine is power. Coal is merely preserved sunbeams. The solar heat acting on one acre in the tropics would, if it were possible to utilise it, produce 4,000 H.P. for nine hours every day. To utilise this heat is not a mere dream; it is certainly possible to convert it into electrical energy by thermo-electric apparatus, though I have not yet heard of its being done.

The earth itself in its daily rotation round its axis is an immense store of energy. If we could by any means reduce a little of this spin we should lengthen the day, but we should obtain energy. Mr. Gisbert Kapp has calculated that if the day increased only one second 100 years hence we should during the whole of this century obtain 10,000,000 H.P. continuously. There is no doubt that the tidal wave is gradually acting upon the earth's spin in this way, but the energy is not available for man, and it is one of our wasted energies.

The tides of the ocean, surging backwards and forwards with unerring accuracy, produce in our estuaries and straits movements of great masses of water which, if utilised as power, could be turned to useful account. Take the case of the Menai Straits, whose breadth at Belan, the entrance from Carnarvon Bay, is 1,188ft., and mean depth about 50ft. This gives a sectional area of water of approximately 60,000 sq. ft., flowing either in or out four times a day at a mean speed of 3 knots per hour, which gives a velocity of 5ft. per second. The effective energy of such a stream would give 6,000 H.P. if it could be utilised. At the present moment not one fraction of this wasted power is employed other than for the motion of ships and boats. The total tidal area of the estuary within the mouth of the River Mersey at New Brighton is 22,500 acres. The mean total volume of tidal water passing in or out of the estuary four times a day is 4,455 million cubic feet. The mean rise or fall of the water above tide level is 10½ft.; that is, the mean vertical range of the tide at Liverpool is 21ft., reaching 31ft. on equinoctial springs and 10ft. on lowest neaps. This would give an available power of about 100,000 horses, if it could be utilised; but this is of course an impossibility. In some estuaries the flood tide is caught by dams in a kind of dock and made to work mills in its ebb, but with a rise and fall of 6ft. it requires a dock area of 10 acres to give 20 H.P. But tide mills are very expensive in their prime cost, and they are rarely resorted to unless Nature has favoured their use by unusually high tides or by convenient geographical configuration. The power executed by tidal rivers is much less than is usually considered. The total tidal energy of the Thames at London Bridge is 320 H.P., from which we could not extract usefully more than 100 H.P., and that only by stopping the whole navigation of the river. The available energy passing through one archway is only 20 H.P. The total available energy of a slow shallow tidal river like the Thames is therefore comparatively small, and its inconvenience would be so great that it is not worth consideration. It is different with a constant flowing river. In a constant moving mass of water the work done per second by the stream depends on the pressure exerted by the water on the effective float area exposed to the stream, and on the rate at which the water flows. The whole energy of a stream running at 5ft. per second (3·4 miles per hour) against a resisting float surface of 5 sq. ft., would exert approximately 1 H.P., and if the efficiency of our machinery be 50 per cent. 10 sq. ft. will give us about one effective horse-power. Hence it is not a difficult problem to utilise the energy of a current of water on a small scale, especially as the energy increases as the cube of the velocity. An extremely ingenious hydraulic motor has been devised by two young engineers, Messrs. Purdon and Walters, of Great George-street, which, moored in a stream, absorbs the energy of the moving water in a novel and effective way, and converts it directly into electrical energy. One is going to be fixed in the upper reaches of the Thames to form a charging station for electric launches. The energy of the falling river will thus be utilised to drive boats up the stream against its own resistance. The quantity of water going down the Seiont from the beautiful lake of Llanberis is approximately five million gallons per day, and it falls about 300ft. Hence the whole energy of the river, if it could be utilised, would supply a constant power of 320 horses. There are already several mills on the stream utilising some of this power; but enough remains, at any rate, to illuminate the streets of Carnarvon with the electric light. Forty million gallons of water will be daily brought to Liverpool from Lake Vyrnwy when the system is complete. The top water level of the lake is 820ft. above the level of the sea. The total energy continuously expended by the fall will therefore be about 7,000 H.P. Of course, much of this energy is expended in overcoming the friction against the sides of the aqueduct, in delivering the water into the houses of the consumers in Liverpool, and in maintaining the service, but there must be a good deal of energy wasted; and it is well worth the consideration of our water authorities whether some utilisation of this wasted energy in waterworks generally cannot be effected so as to deliver it in the form of electrical energy in our streets and buildings. The whole of the streets of Liverpool could be brilliantly lighted by the energy wasted in the Vyrnwy aqueduct.

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Water as a source of energy is found where Nature has placed it, and not where it can be most conveniently used. The electrician has, however, interfered with Nature, and has enabled man to extract the otherwise wasted energy, and to lead it where he wills. The energy of moving water has not hitherto been much sought after in the United Kingdom, because coal is cheap, but now that strikes are rampant, the wise seek wind and water.

Wind is a somewhat fitful source of energy, but it has served its purpose and has done good service in the past. It is still in great request upon the ocean and in lands where coal is dear and air is cheap. It is much used for irrigation, and its energy can be stored either by raising water or by accumulating chemical energy in secondary batteries. Mr. Brush in Cleveland, U.S.A., has used a windmill to light his house, and Messrs. Carwardine and Co., in the City-road, London, utilise about 3 H.P. in this way every evening. An ordinary windmill, having four sails, in a pleasant breeze of 10 miles an hour, gives about 2 H.P.; and the small American circular mill, so much in request now, gives on the average about 1 H.P. The power exerted increases with the area exposed, and with the cube of the air velocity. A wind, blowing at the rate of 10 miles an hour, or, say, 15ft. per second, will exert such direct pressure on a sail 130 sq. ft. in area that it will drive a boat before it with the power of a horse. The largest sailing ship in the world has just been launched at Port Glasgow, which carries a sail area of 57,000 sq. ft., and has a tonnage of nearly 4,000. Such a wind would exert upon her a power equivalent to 440 H.P. Wind is, however, practically available only for small powers, and in exposed positions on land. There are, however, many places where country houses could be supplied with the comfort and luxury of the electric light if this errant force of Nature were curbed and brought under subjection.

While our wants are so readily and so cheaply supplied by our coal fields there is little chance of much attention being directed at present to other sources of energy; but with the diminution of our output, and the cranks of our labour communities, the attention of our manufacturers and of the custodians of our health, safety and comfort must be directed to those neglected energies which are now "wasting their sweetness on the desert air."

ELECTRIC METERS, MOTORS, AND MONEY MATTERS.*

BY PROF. W. E. AYRTON, F.R.S.

The Professor began his lecture by illustrating the dependence of the electrical energy obtained in a given time from an electric current, both on the strength of the current and on the electrical pressure, by comparing the current to a supply through a pipe of coloured water, to be paid for in proportion to the amount of colour supplied. The amount of colour supplied in a given time would be proportional to the product of the amount of liquid supplied in that time by the quantity of colour in every cubic foot of the solution. Similarly the amount of electrical energy supplied from an electric main in a given time would be proportional to the strength of the current by the electrical pressure, and therefore the costs should be measured in the same manner. He pointed out that the Board of Trade unit of electrical energy, the price of which in London varied from 7d. to 8d., was obtained by multiplying a coulomb (the quantity of electricity carried across any section of a conductor in a second by a current of an ampere) into a volt, the unit of electrical pressure, and then multiplying the result by the number of seconds in 1,000 hours. The Professor observed that instruments for measuring electric current, electric pressure, and electric energy were known as ammeters, voltmeters, and wattmeters respectively, the watt being the name given to the unit of electrical energy. The meters employed by the electric supply companies simply measured the number of coulombs passed through them, and should therefore be called coulomb meters. The name was not employed by these companies, who usually called these instruments electric supply meters, possibly because they had no desire to call attention to the fact that what was registered by the meter and what was charged to the consumer were two entirely different things. The quantity measured was the number of coulombs passed through the meter, while the quantity charged for was the product of this by the number of volts at which the electricity was supplied.

Two groups of lamps enclosed in glass fronted cases, showing as models of electrically-lighted houses, were then exhibited, with the same current passing through each of them, but the pressure in one many times greater than in the other. In the former case the model house was brilliantly illuminated, while only a feeble light was obtained in the second case. This was owing to the electrical energy consumed in the one at higher pressure being many times greater than the amount consumed in the other, though in a given time a coulomb meter would give the same indication for each. Thus, in order to convert the readings of a coulomb-meter into Board of Trade units, it was necessary to assume that the pressure kept up in the electric mains from a supply station remains everywhere and at all times constant. It was physically impossible to do this, and, therefore, the Board of Trade allowed a variation of pressure within the limits of 4 per cent. above and 4 per cent. below the nominal pressure, or an extreme variation of 8 per cent. The effects on the light of such a variation of 8 per cent. in the electrical pressure was shown by means of the model houses.

The Professor stated that a series of experiments had been made by himself and his students on the variation in light caused by a variation of 8 per cent. in the pressure. The experiments were confined to Edison-Swan lamps, as these were the only ones which could be used in this country while the existing patent was in force. They found that with these lamps the variation in the amount of light given was about seven times as great as the variation in the pressure; so that under the Board of Trade regulations a 16-candle lamp might vary from 12 to 20 c.p. Even larger fluctuations than this were often allowed to take place unnoticed by the consumer. It was easy to understand that a small fluctuation might pass unnoticed if the change took place slowly; but it would hardly be thought possible that the light could be reduced to half its previous amount without the change being observed.

It was greatly to the credit of the supply companies generally that the variations were usually kept well within the Board of Trade limits; but he could mention places not very far from Albemarle-street, where he was lecturing, at which the fluctuations very much exceeded these limits. He would, therefore, advise consumers to have the pressure on their house mains tested on their own account at frequent intervals. The Professor pointed out that the consumer could obtain legal redress if the variations in pressure exceeded the prescribed limits.

If 97 volt lamps were employed on a 100-volt circuit, then if the pressure fell to 97 volts, it would cause a loss in electrical energy to the consumer of 3 per cent., while if 100 volt lamps were employed, the loss would be 21 per cent. This would point to the advisability of using lamps of somewhat lower voltage than that nominally maintained on the circuit. On the other hand, if the actual pressure were higher than that for which the lamp was constructed, it would diminish the life of the lamp, and so run up the bill for replacing lamps; for the life of a lamp depended more on the maximum than on the mean pressure at which it is run, and a lamp was rapidly destroyed when the pressure was too high, just as a gun which might last a lifetime if not overcharged, might be seriously injured or destroyed by a single overcharge of powder.

The Professor then exhibited some experiments showing that the fact that any particular type of lamp had a certain definite pressure at which it would be used most economically had its exact analogue in gas illumination. Any gas burner had a certain definite pressure at which it gave the greatest amount of light for a given consumption, and, therefore, it was important to use regulators, as the gas regulations specified no maximum

* Abstract of the Friday evening discourse at the Royal Institution on April 8th.

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pressure but only a minimum, and the pressure was frequently found to vary as much as 100 per cent. within 24 hours. In the case of gas lighting, the householder could regulate the pressure by means of taps, or automatically by means of regulators, while a glow lamp on a direct-current main, as on the low-pressure system of distribution, had to be full on or quite off in order to obtain the greatest economy. Though this counted in favour of gas, the Professor observed that the gas supplied in different parts of England varied greatly in quality, while no one had yet discovered any method of adulterating electricity.

The lecturer then gave the following classification of coulomb meters, illustrated by typical forms :—

The Edison Electrolytic Meter, in which electrolysis took place between a pair of zinc plates immersed in zinc sulphate, while, in order to avoid the trouble of weighing, it was made to automatically reverse the current after the passage of a known number of coulombs, and the number of reversals, was automatically registered.

The Motor Coulomb Meter, in which a rotating part revolved at a speed proportional to the current strength, as would always be the case for a motor with permanent magnets. This was illustrated by measurements made with a Gramme magneto-machine employed as a motor. The driving force was here proportional to the current, and the proportionality of the speed to the driving force was obtained by means of magnetic friction. In the Schallenberger meter it was obtained by means of wind vanes, in the Teague meter by means of a vane moving in glycerine, and in the Hartmann and Braun meter by means of a copper disc spinning between magnets. In the case of purely magnetic friction the smallest force would start motion, and with a large force the speed would not be very great, while with mechanical friction a certain limiting driving force had to be attained before motion would begin, after which the speed increased rapidly with the force. This was illustrated by means of a disc of copper spinning between the poles of an electro magnet in one case, and rubbing against a spring in the second case. This showed that mechanical and magnetic friction follow different laws. In either case, however, rise of temperature, and also wear, and the accumulation of dirt would diminish the speed of the motor, which might account for the fact that motor meters were not in favour with the electrical supply companies.

Periodic Meters.—In these the current was cut off at intervals for a length of time, depending on the strength of the current. The Professor had set some students to find how much unrecorded energy they could get from a Frager's meter, which is of this type, by suitably timing the opening and closing of a switch, with the result that the energy obtained was between 300 and 400 times the amount recorded ; these, again, therefore, would be unlikely to obtain favour with the supply companies.

Ayrton and Perry Meter.—This meter consisted of two clocks, one of which was an ordinary timekeeper, while the pendulum of the second clock carried a coil, while a second coil was placed underneath the bob, and the current passed through both coils in the same direction. The attraction between the two coils caused this clock to lose time relatively to the other, and it was found that if the attraction did not exceed a certain definite fraction of the weight of the bob, the difference in time was proportional to the number of coulombs which had passed through the meter. They had proposed that one clock only should be contained in each meter, and its time compared with that indicated by a reliable standard watch carried by the Inspector. Aron, in his instrument, which was constructed on the same principle, preferred to have the pair of clocks in each meter. The Professor explained that this meter had been modified to record electrical energy, instead of coulombs, and stated that the Thomson-Houston Company were now constructing an improved form of it. Another form was constructed by Messrs. Richard Frères, but all the supply companies continued to use mere coulomb meters.

Great difficulty had been experienced in making coulomb meters to register as accurately as gas meters, much of the abuse of which he considered to be undeserved, and due probably to the waste caused by the variations in pressure, but these efforts had at last been crowned with success.

Passing on to the question of heating by electricity the Professor observed that at first sight it would seem that it could not possibly be economical, as the amount of energy equal to that contained in a Board of Trade unit costing 7d. or 8d. could be obtained by burning about a farthing's worth of coal. On the other hand, however, the electrically generated heat could be applied exactly where it was wanted with a minimum of waste, and a joint could be roasted without nearly roasting the cook as well, which was decidedly wasteful. Mrs. Ayrton and the Professor's students had made a number of experiments. One of the results obtained was that it cost about 2d. an hour to maintain an ordinary flat iron at the proper temperature by means of a zigzag of insulated wire embedded in its face. If this were considered high, there was the set-off of the rapidity and ease with which it could be heated at short notice, the constancy of temperature attained, and absence of waste of time in taking it to and from the fire. A frying-pan constructed on the same principle was raised to the temperature required to frizzle butter by the expenditure of 6·84 watt-hours, which at 7d. per Board of Trade unit would cost about a fifth of a penny. An omelette could be made in this frying-pan in about a minute and a-half at about the same cost. These results seemed to show that electrical heating for occasional purposes was decidedly worthy of consideration.

LOAD DIAGRAMS OF ELECTRIC TRAMWAYS, AND THE COST OF ELECTRIC TRACTION.*

DISCUSSION.

AUTHORISED ABSTRACT.—APRIL 9, 1892.

Mr. ALBION T. SNELL had had some experience of tramway working in England, and considered that its success in the end was assured. Whether the final system would be an accumulator conduit or trolley one, he considered as yet uncertain. The accumulator car load diagram showed the current required by one car only, and there were numerous cases of no current when running down hill or stopping, whereas the trolley diagram referred to several cars ; and so the periods of no current were shorter, and there were less variations of current. The crux of the accumulator system lay in the accumulators themselves. On the Barking line there were four cars, which ran 220 miles per day. Each car had three fresh sets of accumulators daily, and in bad weather four. The charging dynamo ran from 10 to 12 hours, and gave on the average 450 E.H.P. hours per day. The energy given to the motors was not easy to determine, as the cells were sometimes run in series, and at other times in two parallels, depending on the number of passengers and the state of the roads. The drivers were always told to start in parallel, and not to work in series if it could be avoided. He estimated that the power averaged about 1 E.H.P. hour per car mile, or 220 E.H.P. hours per day, an accumulator efficiency of about 50 per cent. On an average line he would put engine and dynamo efficiency at about 77 per cent., accumulators at 60 per cent., and motor, gear, and starting devices at 60 per cent., a total efficiency of about 28 per cent. He preferred a single motor to two. There was sufficient adhesion on ordinary roads if the gradients were under 5 per cent. The combined efficiency with a two-motor car was about 5 per cent. less than with a single-motor one ; where there was a field for the double motor was for a line serving between a residential district and a town, the motors being run in series in the town, and in parallel outside. With regard to gearing, he had no experience of gearless motors, but thought they would be best if the stoppages were not frequent. Double reduction had the advantage that the motor was lighter, as it could run at higher speed.

Mr. BLACKWELL had had considerable experience in America. The great mistake that pioneers there, as here, had made was that they calculated the power required, and calculated it much too low. The practice of one road was no criterion of that on another ; they varied so much both in gradients, local conditions, and regularity of load. Their figures were often not comparable ; the line which on paper appeared to be the most expensive often paying the best. The great difficulty in the last four years in America had been the gearing. All kinds had been tried, but he considered that single reduction held the field to-day. He was formerly much opposed to worm gearing, but was now partly converted, but would like to ask the author for some figures on the cost of working with various forms of gearing. As to cost he knew of no case where horses had been replaced on a line by electric traction in which there had not been a great increase of profit. The number of passengers carried on two of the Boston lines increased respectively 70 per cent. and 30 per cent. With regard to Mr. Manville's remarks about interference with the telephones he quite agreed with them. In America the tramway companies tried to

* Paper read by Mr. A. Reckenzaun before the Institution of Electrical Engineers, March 24, 1892.

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avoid interference with the telephones by using double wires, but the two-wire system was found to be impossible on any but the smallest lines, and most unsightly.

Mr. CONDICT agreed that there would be a great advantage in the use of accumulators at the station as steadiers. He believed in the author's plan of dividing up the field-magnets into sections for varying the power, and had gone further in America, where they sometimes used a double armature with a commutator at each end, the two being used either in series or parallel. He had obtained very good results with worm gearing, and had made some tests in which it came out very well, compared to both single and double reduction gear. To the latter he was strongly opposed on account of its noisiness. With regard to weight of his cars, he would put car, battery, and motor at 5,000lb. each, and 80 passengers at 12,000lb.

Mr. JARMAN believed strongly in the accumulator system, especially as they could be put on any ordinary line with horse cars without altering the track. The present horse lines might be divided into two classes, those that paid and those that did not. The former did not want to change to power, and the latter could not afford to do so. In his own work they often ran gradients of 1 in 16 with 68 passengers on a 44-passenger car. Accumulators now gave them but little trouble, but he was careful not to take larger currents from them than he could help. He preferred two motors to one, and always used them in series when possible. In reply to a question from the President, he could not give the cost per car mile including cost of renewals, but proposed to read a Paper on the whole subject at a future date. His cells had been running two years without renewals.

Mr. SELLON objected to the author saying that the expenses of the Blackpool line were 67 per cent. of the gross receipts. There was some £373 to be deducted for part of rent paid to the town, and other items, and this brought the figure down to 43·1 per cent. Two of the winter months also they were running at a loss. Taking from April to September only, the cost was £1,524, and the receipts were £5,570, giving 27 per cent. With regard to accumulator traction, he believed one set had run 4,000 miles, with 785 discharges and no renewals.

Mr. CROMPTON said that the reason cells did not last was that the outer surface of the active material was always being jarred off. The right direction to work in was to try and get some non-pasted cell, and also to improve the springs of the cars. In crowded cities he thought the accumulator system was the only feasible one.

Mr. TROTTER said the load diagrams nearly gave as much useful information on mechanical matters as on electrical ones. Much could be learnt from these diagrams as to the effect that a heavy fly-wheel on the engine would have, and to what extent governors would be useful. For integrating the curves to find the total amount of power, he drew them on the oiled paper used in copying letters, and then cut them out and weighed them. The circumscribed rectangle represents a certain number of ampere hours, and the proportion between the weight of the curve and that of the remainder gave the load factor.

Mr. WILLANS said the mean current appeared only to be 30 per cent. of the maximum, which was a very wasteful arrangement. Americans rather objected to using compound engines on the ground that they were not economical at low loads; this, however, was not correct. It was true, however, that a compound had to be larger than a simple engine, as in the former steam would not be admitted during the whole stroke as it could in a single engine on emergency. Mr. Baker had brought a dynamo with him from America with a 10-ton fly-wheel, and he thought a good deal was to be done in storage by that means. He agreed with a previous speaker that it would be well to start the motor free, and bring it into gear by a friction clutch, as it should save a great deal of loss in the leads, and the inertia would help the starting instead of opposing it, as it did when starting from rest.

Mr. SWINBURNE wished to know why such large H.P. was required; 30 H.P. of motors on a car usually drawn by two horses. Mr. Field had told him he was running a car with a 2-H.P. motor, coupled direct through rods, thus avoiding gearing loss.

Mr. FRAZER said there was no need to use much power to start a car, if you only did it slowly enough. The starting current at Barking, with all resistance in, was 40 A., and the running current about 30 A., the maximum being 70 A., for 200yds. on a 3 per cent. gradient. The voltage was 100. Time required to get up speed (eight miles an hour), half a minute.

Mr. RECKENZAUN, in reply, said, with regard to the Southwark railway, it was running under different conditions to a tram line; being worked by signals, it could be arranged that more than two trains need not start at once. He thought that if Mr. Baker had added a competent English engineer to his staff of American ones he would have saved much of his preliminary expense. He spoke of the engine at Roundhay working much under power, its average output was certainly only 75 H.P., but a maximum of 165 H.P. being sometimes required the engine could not well have been much smaller. With regard to starting the motor light and then throwing it into gear he had tried this nine years ago, and found it quite useless; even when there was a 120lb. fly-wheel on the motor it was pulled up before the car started. The 17-ton car mentioned by Mr. Russell he thought a very excessive weight. The ordinary American cars, with passengers, weighed about nine tons. Two motors he considered much better than one, and American practice confirmed this view; mechanical coupling of the two sets of wheels he thought bad, as it produced so much friction. He quite agreed with Mr. Crompton's remarks on batteries. He could not quite understand the line which Mr. Swinburne spoke of as being said to run with 2 H.P.; he himself had begun with one 4 H.P. motor, but it would not do. The Americans now use two 15 H.P. motors. If one breaks down the other will run the car, and the two together are wanted when a car leaves the rails. The pull required to start a car he had found from several tests was from 100lb. to 200lb. per ton

LEGAL INTELLIGENCE.

Wilson and Wife v. National Telephone Company.

In the Queen's Bench Division, on Tuesday, before Mr. Justice Laurence, the above action was heard.

The plaintiffs, Mr. Albert Wilson and his wife, claimed to recover damages for personal injuries sustained by the latter through the negligence of the defendants' servants. The Company did not dispute their liability, and paid £75 into court, contending that that was sufficient to meet the plaintiffs' claim. While some of defendants' workmen were engaged in securing a pole at the top of a house and placing some wires along the coping, some bricks were displaced and fell down, Mrs. Wilson being struck in the back and knocked down. The defence was that the claim was a greatly exaggerated one.

Mr. Morton Daniell appeared for the plaintiff; and Mr. Cock, Q.C., and Mr. Bremner for the defendants.

The learned Judge came to the conclusion that the amount paid into court was sufficient to meet plaintiffs' claim, and gave judgment for the defendants with costs.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 2, 1892.

The Progress of the Overhead Trolley System.—The use of the overhead trolley system of electric street car propulsion is gradually making its way into the large cities of this country. As is well known, Boston was the leader in this regard, having now in operation between 200 and 300 miles of overhead trolley line. St. Paul and Minneapolis have for some time had systems aggregating not far from the same number of miles; while Cleveland, Buffalo and Rochester, as well as St. Louis and Cincinnati, have systems that have demonstrated the practicability of the trolley for large cities. Brooklyn recently fell in line by granting to all the roads of that city permission to adopt this system on their lines; and Philadelphia has now placed itself on record as favouring the same method of street car operation for its business and other thoroughfares. Last week the aldermen of that city granted permission to every street car line in the city to use the overhead system; and notwithstanding the mayor's veto in view of the citizens' protest against the granting of the franchise without a payment of a certain part of the earnings in return for this valuable franchise, the aldermen have just passed the ordinance over the mayor's veto; and so one more of the metropolitan cities of the country will at once proceed to substitute the electric motor for its horse methods of operation.

The Marcel Deprez Transmission of Power Patent.—Considerable comment has been caused during the past ten days by the issue of a patent to Marcel Deprez and Jules Carpentier by the United States Patent Office, which seems to cover broadly the transmission of power by means of step-up and step-down transformers. This patent, as many of your readers will remember, was granted to the same parties in England and France in 1881. It was not, however, applied for in this country until 1888. It is stated by those who are in a position to be thoroughly acquainted with the facts that the patent cannot be held to be valid for two reasons; first, that it was applied for after two years of public use, and, second, their patent as issued does not cover the same ground as the English and French patents mentioned above, but that it was juggled into the shape in which it was issued through the ingenuity of the patent attorney who had the matter in hand.

The Comparative Efficiency of One or Two Motors for Cars.—The Chicago Electric Club has been discussing a question which has been of interest to electrical engineers ever since the first electric traction systems came into use in this country, namely, the comparative efficiency of one and two motor car equipments. The question has always been a burning one, and does not yet seem to be any nearer settlement than it was years ago. A one-motor car equipment, of course, is generally understood by engineers to mean a single motor connected to both car axles.

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CORRESPONDENCE.

COMPOUND WINDING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I beg to offer a correction of a slip made in your able leading article of last week. The first constant-potential machines made in England were those turned out by Messrs. R. E. Crompton and Co. in the end of 1882, but I had nothing to do with them. They were made under the direction of Mr. Gisbert Kapp.

My connection with the subject was earlier. In February, 1882, I converted a Siemens shunt dynamo into a constant potential machine. This was in Paris. In the spring of the same year I ordered three constant-potential machines from the Brush works at Cleveland. Mr. Brush has stated that he knew all along that his series-shunt machines would give constant potential. I still hold that he did not know it till I ordered these three machines.

The constant-potential winding was first published by Edison's American patent. Hopkinson also mentions compounding up in his three-wire patent of July, 1882. I think Mr. F. C. Phillips also took out a patent about the same time. Messrs. Crompton and Kapp's specification was filed after the invention had been published elsewhere; all the same, the credit is due to them of making the first constant-potential machines in this country, and fully realising the importance of the invention.

Of course Mr. Varley was the first to use double winding, namely, in 1876, but he did not use it for constant potential.—Yours, &c., JAMES SWINBURNE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to correct a slight error in your leader in last Friday's paper. You say that "everybody knew that the first real compound-wound dynamo was built by Mr. Crompton, to the designs, we believe, or under the superintendence of Mr. Swinburne."

The first four compound-wound dynamos were made for Berechurch Hall, near Colchester, in the autumn of the year 1882, and the patents were taken out by Mr. Kapp and Mr. Crompton conjointly. One of these machines was running about the middle of October, and all were down and running by November 10th of that year, and were inspected by Mr. Heaphy on that date. To the best of my belief Mr. Swinburne had nothing to do with Messrs. R. E. Crompton and Co. until he was engaged to fill Mr. Kapp's place in December, 1885.

I may mention that I had the running of those very machines, after they were put down at Berechurch Hall, for about three weeks, after which I returned to the works at Chelmsford. Trusting this may be of sufficient interest to be inserted in your paper, I am, yours, &c., SYDNEY STOKES.

6, Osborne-terrace, Westcombe Park, Blackheath, S.E.
April 12, 1892.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to a statement which occurred in your leader of last week, that you believed Mr. Swinburne to have designed and superintended construction of the first compound-wound machine for constant potential, allow me to say that you are undoubtedly in error. In part of 1882 I was in charge of the test-room at Chelmsford, and was associated with Mr. Gisbert Kapp in carrying out experiments with shunt-wound machines with Bürgin armatures. It was during the course of those experiments that Mr. Kapp hit on the idea of combining the shunt and series winding, and within a very short period we had tried and ascertained the value of the combination. I believe a patent was applied for in Messrs. Kapp and Crompton's joint names, or *vice versâ*.

I think the first compound machines put into practical use were those put down at Berechurch Hall, near Colchester, the residence of Mr. Coope, M.P.—Yours, &c., W. B. SAYERS.

Glenwood, Bearsden, near Glasgow.

[It would be worth while making a slip now and then, if so much interesting historical information could be always elicited. Mr. Swinburne's claim that he was the first to "compound" a dynamo has never yet been disputed. It was the recollection of this that led to the mistake.—Ed. *E.*]

GASSNER'S DRY CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Those of your readers who are telegraph engineers or those in any way interested in batteries, and having no experience of *dry* cells, no doubt would like to know something of their practical value; so I will ask you to permit me to trespass a little upon your space, and furnish a few particulars of the Gassner Dry Battery, which I have given my attention to lately.

The full details of the construction are known only to the inventor and the makers; but I think the following will serve to give a general idea:—

The negative element is carbon specially manufactured, distinguished by its remarkable porosity, and contains a most efficacious depolarising chemical. Its form is that of a hollow cylinder; the upper parts are well insulated, so as to prevent corrosion at the terminals.

The positive element is zinc, and forms the outside of the cell, and is of sufficient thickness to resist all chemical reactions inside, as far as the exterior is concerned, so that holes will not be eaten through it.

The electrolytic mass inside the cell consists of exciting salts solidified by means of gypsum and water. There is no liquid to drain out, and the great advantage of this mass claimed by the inventor is that its peculiarity prevents the formation of any incrustrations on either element, in consequence of which there is little or no local action.

Last November the manufacturer supplied me with four of these cells, and sent them done up in a bundle by *parcels post* from Milan to Malta. They were by request taken out of a large number without any special selection, so as to represent a true average, but of course with all latest improvements.

My first tests gave the E.M.F. of the battery of four cells as 6·048 volts, or 1·512 volts per cell at a temperature of 71°F. I found the variation to be about 0·3 per cent. per degree Fahrenheit. The internal resistance was as near as possible 0·25 ohm per cell.

Since their receipt I have worked them in various ways; on testing, speaking, and bell circuits; also used them in boats repairing cables, and all kinds of ship and shore work.

The following are the results of tests I obtained of these cells when subjecting them to a severe trial of their sustaining qualities.

1. Two of the cells, Nos. 3 and 4, were placed in circuit of 61 ohms, containing a tangent galvanometer.

Current strength on the first application = 42 milliamperes.
" " after 20 hours' " = 37 "
or a fall of only 5 milliamperes in twenty hours.

2. The same two cells were then practically placed on *short circuit*, the tangent galvanometer having a shunt of four feet of cable core, or only 0·006 ohm, the fall in the current strength being as follows:—

Time.		Deflection.		Current.
Min.	Sec.	Deg.	Min.	Amperes.
0	15	45	0	4·500
0	30	43	0	4·196
0	45	40	30	3·843
1	0	38	30	3·579
2	0	35	0	3·151
3	0	33	0	2·922
4	0	31	30	2·758
5	0	30	15	2·624
6	0	29	20	2·529
10	0	25	0	2·098
15	0	23	20	1·941
20	0	19	0	1·549
25	0	10deg. to 15deg. fluctuating.		—

3. E.M.F. of the cells after the above test,

No. 3 = 0·971 volts.
No. 4 = 0·890 "

representing a mean loss of 31·4 per cent., corrected for co-efficient of temperature variation.

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4. Nos. 1 and 2 cells were used for several hours in calibrating galvanometers and other work, their E.M.F. falling from 1·482 volts to 1·239 volts.

5. All four cells were allowed to rest for 24 hours.

Cell.	Normal value at 60°F.	Value after above tests	Value after 24 hours' rest.
No. 1	1·482 volts.	1·239 volts.	1·325 volts.
No. 2	,,	1·239 ,,	1·352 ,,
No. 3	,,	0·971 ,,	1·278 ,,
No. 4	,,	0·890 ,,	1·258 ,,

From my experience of this neat and handy form of cell, I can strongly recommend them for general use, more especially on board ship, where portability is a very great consideration. I understand they are employed in the Post Office and by several Continental telephone companies with much satisfaction.

In the hands of novices, for houses, offices, workshops, or steamships, these cells I should say would be found most suitable; and the increase in monetary value over the Leclanché or any other form of battery is more than compensated for by the cleanliness, no attention wanted, and the fact that they can be stowed anywhere, and in any position, giving out no smell whatever, and without fear of getting broken.

As to the life period of these cells of course I cannot give any idea. The following are the present values of the above-mentioned cells after four months' work on various circuits, including short-circuit and considerable knocking about:—

No. 1 = 1·228 volts
No. 2 = 1·355 ,,
No. 3 = 1·358 ,,
No. 4 = 1·179 ,,
} @ 74° F.

or a mean loss of 12·6 per cent. The manufacturers state that a battery of these cells has been working over two years and still remains in good order: but this has to be verified by the experience of others. Perhaps some of your numerous readers can enlighten us on this point.

It is worthy of note that these cells can be regenerated by charging them in the same way as accumulators, without the electrolytic mass becoming liquefied, recovering their loss, and attaining almost normal values.

I shall continue to watch the changes in these cells, and wait with much interest their ultimate decline, which is now the only question of their practical success and superiority in many ways over the existing forms of batteries.—Yours, &c.,

Gibraltar, March 20, 1892. W. H. Cottrell.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.

The tenth annual edition of the above well-known annual is now ready, price 7s. 6d.; post free, in the United Kingdom, 8s. 3d.; abroad (with the exception of a few countries), post free, 8s. 10d.

The edition consists of between 900 and 1,000 pages, and special care has been taken to make the Directorial division of the book, which has been considerably extended, thoroughly accurate and reliable. In this respect no possible comparison can be made with any similar publication.

To the Handbook division has been added several features which will be found of service to the Electrical and Allied Trades. The Digest of the Law of Electric Lighting has been thoroughly revised and brought up to date, and the most recent Board of Trade Regulations are also included. The various tables and tabulated statements have been remodelled and amplified; and a new feature is the tabulation of valuable information respecting Electrical Limited Liability Concerns.

An important feature is the space devoted to the officials of Foreign and Colonial Governments who have the superintendence of contracts and the giving of orders for electrical plant and apparatus; and as this has been kindly supplied by the various Government departments, it can be relied upon, as can also the particulars given respecting the Home Government departments.

The profession will find "The Electrician" Electrical Trades' Directory and Handbook a trustworthy work of reference, and purchasers of plant and apparatus may confidently turn to its pages for the names of all the principal firms supplying their requirements. Nearly every firm of any standing in the Electrical and Allied Trades is represented in its advertisement pages.

A digest of the contents of the book will be sent on application.

Tenders Invited.—Mr. Robert Mitchell is prepared to receive tenders for a complete installation of telephones and electric bells to be erected at the new Hotel Metropole, Sackville-street, Dublin. Plans and specifications may be had from Mr. Walter Leake, of 30, Victoria-buildings, Manchester, on receipt of an entrance fee of £1. 1s., which will be returned on receipt of a bonâ fide tender. Tenders must be sent in to Mr. Walter Leake not later than April 27th. Further particulars are given in our advertisement pages.

——— The Directors of the Woolwich District Electric Light Company (Limited) invite tenders for the supply and erection of the necessary machinery, &c., for a 1,000 light central station, including underground mains. Further particulars, including plan of the district to be lighted, may be obtained after the 19th inst. at the offices of Mr. J. A. Findlay, secretary, 11, St. Helen's-place, E.C., on payment of £1. 1s. Tenders have to be in by 11 a.m. Monday, May 2nd. Further particulars are given in our advertisement columns.

——— The Bradford Corporation invite tenders for the work in connection with the extension of the electricity station in Bolton-road, Bradford. The work includes new roofing, iron work, and brick and concrete flooring. Tenders have to be in by April 26th. Specifications and plans can be seen at Mr. Shoolbred's offices, at 13, Victoria-street, Westminster, or at the offices of Mr. McGowen at the Town Hall, Bradford.

——— The Corporation of Huddersfield invite tenders for the electric wiring and electric light fittings for the Town Hall and Borough offices. Tenders (addressed to Mr. A. B. Mountain, Borough Electrical Engineer, 1, Peel-street, Huddersfield,) must be in by 10 a.m., on Thursday, the 28th instant.

Belgrade.—The contract for the plant for the electric lighting at Belgrade has been secured by the Continental Edison Company of Paris. Six 60-unit Edison machines are required for the incandescent lamps, and three Sperry-Edison dynamos will supply 40 arcs each. The dynamos will be driven by three Weyher Richemond engines of a new type. The boilers are to be by Babcock and Wilcox, Limited.

Dissolutions of Partnership.—The partnership between M. Mercier and G. S. Corlett, trading as Mercier, Corlett and Co., electrical and mining engineers, &c., at Wigan and Bolton, has been dissolved.

——— The partnership between H. E. Childs and F. C. Berry, of 22, Denmark-street, Soho, London, electrical engineers (trading as Thurkle and Co.), has been dissolved.

Fire at Messrs. Davis and Timmins (Limited).—We regret to announce that on Sunday morning last the premises of Messrs. Davis and Timmins (Limited), of 24, Charles-street, Hatton-garden, E.C., were destroyed by fire. The fire broke out in the adjoining premises, and in a short time the whole of the valuable plant and machinery and extensive stock were destroyed. We are pleased to learn that the firm were fully insured. It will, however, take some time before they can replace their loss, as a large proportion of the tools and special labour-saving machinery used will have to be specially constructed. In a circular issued by the firm, they notify that they have arranged for the present to carry on the whole of their business at their York-road, King's Cross, Works, pending the rebuilding of the Charles-street premises. Although most of the books have been saved, Messrs. Davis and Timmins will be obliged if customers will furnish them with copies of any orders unexecuted, and fresh samples.

General Electric Company.—The third edition of the illustrated catalogue of telephones and telephone accessories has been issued by this Company. A large number of instruments are illustrated, receivers and transmitters being mounted in a great variety of patterns. Insulators, batteries, wire, and tools are to be found in this catalogue, which includes estimates for the erection and fitting of installations.

Electric Mining Plants.—Messrs. John Davis and Son, of Derby, notify us that they have completed, or have in progress, five or six plants of considerable size, for lighting or combined lighting and power purposes. At the Swanwick Collieries, near Alfreton, Derbyshire, a small plant was erected two years ago for lighting the surface at one of the pits; and this has been extended to the underground roads, and to another pit 500yds. distant, and also drives a pump at a distance of about a mile from the dynamo. The plant is subsequently to be enlarged by the addition of a second dynamo, and of a continuous-current transformer, which will charge a battery at Alfreton Hall, the residence of Mr. C. R. Palmer-Morewood, about two miles distant. At the Sheffield

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Coal Company's Birley Colliery, a large lighting plant is in course of erection, and a similar one has been lately finished at the Bolsover Colliery, on the Duke of Portland's estate. The latter plant lights the whole colliery and brickworks, and also the manager's house. At the New Morgan Gold Mining Company's mine, near Dolgelly, North Wales, a lighting plant, with two dynamos driven from a turbine, has been erected, to light the stamp mill, compressor house, mine, &c. The dynamos are placed in a portion of the stamp mill; and the mains to the mine, which is about one mile away at the head of the ravine, are of bare copper, carried on poles. In this case, as the water-power is rent free, electricity is greatly superior in economy over oil, which is the only other available means of lighting. Messrs. Davis have also in hand a very large and complete colliery lighting plant.

W. T. Henley's Electric Light and Power Company (Ltd).—By a resolution passed March 21st, and confirmed April 7th, this Company is to be wound up. Mr. J. H. Stephens, C.A., of 6, Clement's-lane, E.C., is the liquidator.

Muir, Mavor, and Coulson (Limited).—By a resolution confirmed March 31st, this Company has been wound up, Mr. T. A. Craig, C.A., acting as liquidator. Claims should be sent to liquidator at 139, St. Vincent-street, Glasgow, by April 18th inst.

Carbrook Forge and Steel Company (Sheffield).—Mr. J. W. Randall, of 110, Cannon-street, E.C., has been appointed London representative of this firm.

"Adressbuch der Elektrotechnik und verwandter Zweige, 1892."—We have received from Herr A. Balck the first issue of his Directory of the electrical and kindred trades in Germany, Austria, and Switzerland. Alphabetical lists of firms in these three countries are followed by a comprehensive classified trades' list, and this again by lists of the principal central electric lighting stations and of the electric railways and tramways in operation in the countries named. An appendix enumerates the various principal technical universities and schools, technical institutions and societies, &c. The Directory makes a creditable commencement, and promises to become a useful annual.

The "Local Government Journal."—The proprietors of the old-established *Metropolitan* have altered the title of their publication to the *Local Government Journal*, by which name it will in future be known. The *Metropolitan* was established in 1872, and is recognised as the leading journal for all kinds of contracts and tenders, and Local Government notices.

PATENT RECORD.

The following list of applications for patents and specifications has been compiled for this journal by Mr. J. C. Chapman, *patent and registration agent, Fel. Chartered Inst. Patent Agents, of 70, Chancery lane, W.C., from whom any available information may be obtained.*

APPLICATIONS FOR PATENTS

Note.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

March 17, 1892.

5,245. J. Pedder. Appleton-in-Widnes. Improvements in the production of caustic soda and carbonate of soda by electrolysis, and in apparatus therefor.

5,256. G. Percival. Cork. Improvements in the mechanical construction of dynamo armatures.

5,311. J. C. Richardson. London. Improvements relating to the construction of electrodes for electrolytic purposes.

March 18, 1892.

5,365. Munro's Electrical Manufacturing Co. (Limited), and J. MacFarlane. Glasgow. Improvements in joints for electric light fittings.

5,380. G. W. Ready and J. Palfreeman. London. An improvement in pendant electroliers for electric lighting.

5,383. J. A. Kingdon. London. Improvements in the means of synchronising alternating-current dynamos and of working them in parallel and taking them out of parallel.

5,404. J. H. Steward. London. Improvements in magnetic compasses.

5,409. G. E. B. Pritchett and T. W. Pritchett. London. Improvements in secondary batteries.

March 19, 1892.

5,432. E. D. Taylor. London. An improved automatic electric security lock.

5,442. F. F. Bennett and F. A. Colley. Sheffield. Improvements in galvanic batteries.

5,474. A. Hirsch. London. An improved incandescent arc lamp.

March 21, 1892.

5,498. C. A. Stevenson. Edinburgh. Electrical pilot.

5,511. W. S. Hedley. Brighton. Means for arranging automatic shunt circuits, for electrical purposes.

5,515. J. Jergle. London. Improved regulating device for the carbons of electric arc lamps.

5,526. Siemens Bros. and Co. (Limited), and F. G. Baily. London. Electric apparatus for producing flashes.

5,528. H. S. J. Booth. London. Improvements in coin-freed telephone apparatus. (C. Hermann, France).

5,546. J. W. Swan. London. Improvements in or connected with the electrolytic deposition of copper or other metals.

March 22, 1892.

5,579. J. Swinburne. Teddington. Improvements in dynamo-electric machines and motors, in direct current distribution, in leading in wires for incandescent electric lamps, and in the insulation of electric transformers.

5,618. T. Boyden. London. Improvements in alternate-current transformers.

5,634. J. Y. Johnson. London. Improvements in electrically controlled elevators and switch mechanism for use therewith. (N. Hiss, United States).

5,645. L. Pyke and E. S. Harris. London. Improvements in or connected with electric batteries.

5,652. H. H. Lake. London. Improvements in and relating to conduits for electric railway conductors. (The Thomson-Houston International Electric Company, United States).

5,654. A. C. Reignier. London. Improvements in dynamo-electric machines.

5,655. J. P. Rees. London. An improved electric safety lamp.

March 23, 1892.

5,712. G. L. Anders and W. Köttgen. London. Improvements in and connected with diaphragms of telephones.

5,732. J. A. Lea, J. F. Lea and A. H. Lea. London. Improvements in or connected with electric light fittings.

5,735. H. Hirst. London. Improvements in connections for electric lighting.

5,748. G. Shann. London. Improvements in electric meters.

5,750. E. H. Johnson. London. Switch for electrical circuits. (Date applied for under Patents Act, 1883, Sec., 103, August 25, 1891, being date of application in United States).

March 24, 1892.

5,812. H. R. Low. London. Improvements in arc electric lamps.

5,814. Sir C. S. Forbes, Bart. London. Improvements in microphones and in apparatus connected therewith.

March 25, 1892.

5,828. C. H. Falkenstein and K. K. Falkenstein. London. An improved method of rapid tanning with the aid of electricity.

5,850. R. J. Urquhart. Manchester. Improvements in or connected with telephone fittings.

5,870. A. O. Arnesen and E. Wölner. Liverpool. Magnetic course indicator.

5,891. W. T. Mathews. London. Improvements in or connected with holders or supports for the ear tubes of telephones.

5,899. E. F. M. Loevenbruck. London. Improvements in apparatus for adjusting and regulating the carbons of electric arc lamps.

March 26, 1892.

5,931. W. L. Spence. Manchester. Improvements in the construction of multipolar dynamo-electric machines.

5,933. G. Sacco. London. New accumulator battery for telegraph offices for military telegraphs in the field, also for lighting trams, omnibuses, carriages.

5,954. F. Brown. London. Improvements relating to voltmeters.

5,959. J. Spisd and H. Nowak. London. Improvements in accumulators.

March 28, 1892.

5,971. S. W. Baynes. Bradford. Improvements in underground conductors for the distribution of electricity.

5,982. A. H. Sanderson. Bournemouth. Improvements in joints and connections for electrical purposes.

5,988. J. S. Raworth and W. Geipel. London. Improvements in or relating to the distribution of electricity.

6,006. T. Parker and A. E. Robinson. London. Improvements in the treatment of electro deposits of metals.

6,007. T. Parker and A. E. Robinson. London. Improvements in or connected with cells for electrolysing chloride solutions.

6,015. R. R. Harper. London. Improvements connected with shades and shade or reflector holders for incandescent electric lamps.

March 29, 1892.

6,030. W. P. Thompson. Liverpool. Improvements in insulated electric conductors. (J. B. Williams, United States).

6,058. W. F. Taylor. Croydon. Improvements in machinery for the purpose of hardening and tempering metals by electricity.

6,061. A. Whalley. Cheshire. Improvements in telephone switchboards.

6,083. F. S. Smith. London. Improvements in incandescent electric lamps.

6,033. M. Boehm. London. Improvements in the manufacture of filaments for incandescent electric lamps.

6,095. R. Belfield. Strawberry Hill. Improvements in conductors for electric railways or tramways.

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SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

3,984. PATIN. Electric arc lamps.
4,669. HIRBEC. Generating electricity.
4,682. DE FERRANTI. Electrical supply systems.
4,684. MAYES. Measuring and adjusting magnetic force.
6,048. NORTH. Electric power apparatus.
6,489. PRYKE. Electric incandescent lamps.
6,793. CHAMPION. Producing pyrotechnic, &c., effects by electricity.
7,850. HORN. (Strowger). Telephone exchanges.
7.858. SNELL AND OTHERS. Electrical switches.
7,878. ROWAN AND MCWHIRTER. Preventing ignition of gases in dynamos, &c.
7,911. GRIMSTON. Electric switch.
7.912. GRIMSTON. Electric capstan.
7,937. COX. Electric resistance devices.
8,153. SIEMENS BROS. AND CO. (LIMITED). (Siemens and Halske). Electrically propelled cars.
12,107. DOW. Electric light, &c., fittings.
19,965. LOVE. Electric conductors.
21.551. PITT. (Sautter, Harlé and Co.) Electric light projection.
22,037. LAKE. (Wright). Printing telegraph receiving instruments.

1892.

1,313. SHORT. Electric motor cars.
1,557. THRELFALL. Electro-magnetic apparatus.
2,448. WENTZ. Telegraphic relays.
2,497. HUNT. Magneto-electric machines.
2,724. GRIMM. Electro-therapeutical apparatus.
2,744. HOFFMANN. Telephonic instruments.

COMPANIES' MEETINGS & REPORTS.

New Australian Electric Company.

The third annual meeting of shareholders in this Company was held recently at Fink's-buildings, Melbourne. Mr. B. J. Fink presided.

The SECRETARY (Mr. H. Ashworth) read the notice convening the meeting, and the report of the Directors. The balance-sheet and statement of accounts for the twelve months ended December 31, 1891, showed a net profit for the year of £6,474. 1s. 10d., which, added to the amount brought from last year, gave a balance of £11,190. 6s. 6d. to the credit of profit and loss. The Directors state that the plant at the Richmond lighting station is in first-class order, and its working fully realised the anticipations of the Directors with respect to its efficiency and economy. The amount of business done by the Company during the last twelve months had been most satisfactory. Lighting had been extended in many directions, and numerous orders for installations and plant had been executed. In 1889 an equivalent of 6,954 incandescent lamps was supplied; in 1890 the number was 9,086, and in 1891 14,566; and at the present time the supply was increasing at the same ratio. During the year Mr. W. Brookes had resigned his position as a Director, and Mr. Wilfrid N. Kernot had joined the Board. Prof. W. C. Kernot (the Chairman) was at present on a visit to Europe and America, and was obtaining information on electrical matters which would be of service to the Company.

The CHAIRMAN, in moving the adoption of the report and balance-sheet, said the works of the Company were quite equal to any works of the kind in the old world. There had been uninterrupted smooth working during the past few months, and several thousands of pounds had been spent on the extension of the buildings, which would now admit four more engines, or rather more than double the previous capacity. They had not been able to erect additional plant because additional capital would be needed to do that, and the unfortunate financial times stood in the way of successfully placing more shares on the market. The plant was fully employed, and the income was now a very large one. The rumours as to the dangers of electric lighting had been pretty well dissipated, as there had been no accident of any kind during the past 12 months. The Directors had to congratulate the shareholders on the very satisfactory, he might almost say brilliant, results of the last year's operations. A handsome dividend could have been declared, but every pound was needed for the business, as would be admitted by every shareholder who might choose to go and see the magnificent station and plant at Richmond.

The motion was seconded by Captain ROWAN, and carried unanimously.

Prof. Kernot, Mr. B. J. Fink, and Mr. J. F. Levien, M.L.A., were re-elected Directors.

Maxim-Weston Electric Company (Limited) (in Liquidation).

A general meeting of the members of this Company was held at the Cannon-street Hotel on Friday last, under the presidency of Mr. John Marks, one of the liquidators.

The CHAIRMAN explained that at the time the liquidators were appointed there was heavy litigation pending with regard to a large proportion of the Company's affairs. The claims by and against the Company had, with the approval of the Directors of the new Company, been settled, with the exception of the Watt litigation, and the claims by and against Palmer's Ship Building Company and the Brighton Corporation. The liquidators recovered against Mr. Watt £1,000 with costs in both the actions raised by him. Although they gained the case against the Brighton Corporation, the arbitrator awarded the Corporation damages exceeding by about £7 what was recovered by the liquidators. The official referee had ordered a return of the plant to the Company, and awarded Palmer's Company damages for an inefficient installation, and the costs. Having explained the various items in the report and account submitted, he concluded by moving their adoption.

Sir HENRY HOARE seconded the motion, which was carried.

Resolutions were afterwards passed, disposing of the books, accounts, and documents of the Company, and of the liquidators; and voting, in various proportions, the remuneration of the latter.

At a meeting of the new Company, held subsequently, similar resolutions were adopted.

Indo-European Telegraph Company (Limited).

The following is the Directors' report for 1891, which will be presented to the twenty-fifth ordinary general meeting, to be held at Winchester House, E.C., on Wednesday, the 27th inst., at noon.

The Company's revenue from all sources for 1891 amounted to £116,699. 3s. 1d., as compared with £113,807. 3s. 11d. for 1890, showing an increase of £2,891. 19s. 2d. The expenses were:—On commercial and general account, £30,581. 5s. 3d.; on maintenance account, £30,527. 7s. 7d.: total, £61,108. 12s. 10d., as against £57,901. 19s. 7d. for 1890, an increase of £3,206. 13s. 3d. Deducting the above expenses, taking credit for £4,168. 16s. 7d. brought over from 1890, and debiting income-tax, there remains the sum of £58,483. 15s. 4d.

From this amount £10,000 has been placed to reserve, and that sum, together with £10,625 amount of interim dividend, have to be deducted, leaving a balance of £37,858. 15s. 4d. The Directors now propose the declaration of a dividend for the six months ending December 31st of 17s. 6d. per share, making, with the dividend already paid, 6 per cent. for the year and a bonus of 20s. per share, both free of income-tax, making in all 10 per cent., carrying forward £5,983. 15s. 4d. to the credit of 1892.

The new rules, regulations, and tariffs of the International Telegraph Convention settled at Paris, have had full effect since July 1st last; but, as anticipated, have had no material influence upon the Company's revenue.

The arrangement with certain of the Australian Colonies for the introduction of a greatly reduced tariff between Europe and Australia came into force on May 1st last. It will be remembered that Queensland and New Zealand decided to remain outside the above arrangement. The outcome of the reduced rate, so far, has been an increased traffic, coupled with a diminished receipt. On the whole, however, the results have been sufficiently promising to induce the Governments and Companies concerned to continue the experiment for at least another twelve months.

The following Directors retire by rotation, and offer themselves for re-election:—H. Weaver, Esq., and L. Delbrück, Esq. The auditors, Messrs. C. F. Kemp, Ford, and Co., public accountants, retire and offer themselves for re-election.

Oriental Telephone Company (Limited).

The following report of the Directors of this Company for the year ended December 31st last, has been issued, and will be presented at the twelfth ordinary general meeting of the Company, to be held at the Cannon-street Hotel, on Wednesday, the 27th inst., at one o'clock.

The revenue account for the year ended December 31, 1891, shows a balance to credit of £8,918. 13s. 10d., which has been transferred to profit and loss, and including £2,250. 19s. 9d. brought forward from the previous year, a balance remains for disposal of £11,169. 13s. 7d. The Directors propose to deal with this as follows:—To write off £257. 0s. 4d., legal and other expenses caused by the action brought by holders of vendors' shares; £1,466. 4s. 8d., in reduction of capital expenditure; to add £3,000 to reserve fund, which will then stand at £10,000; and to pay a dividend of 2¼ per cent., free of income tax, on the total paid-up capital of the Company, carrying forward £1,857. 16s. 4d.

As the shareholders are aware, a large portion of the earnings of the Company are in silver currency; and, owing to the low exchanges which have lately been ruling, the profit of the year has been somewhat diminished.

As mentioned in the report of last annual general meeting, a copy of which was sent to each shareholder, proceedings were taken by a holder of vendors' shares to restrain the Directors from distributing the profits of the Company in the manner indicated in the last annual report and accounts. The Court having upheld the action of the Directors, the distribution for the past year will be made in the same manner, the 2¼ per cent. on the entire paid-up capital of the Company being equivalent to £3. 12s. 2d. per cent. on each ordinary share of 11s. paid, issued prior to February 4, 1886.

The Indian Companies continue to improve. The Bengal Company has been able to increase its dividend by ½ per cent, the distribution for 1891 being 5½ per cent., whilst the Bombay Company has declared a dividend equal to that of the preceding year, viz., 4 per cent., transferring 10,000 rupees to its reserve and depreciation fund. The Bengal Company already possesses a reserve fund in cash of 50,000 rupees.

The Telephone Company of Egypt, after payment of debenture interest, has declared its usual dividend of 6 per cent. on the preferred shares, carrying forward £1,414. 17s.

The China and Japan Telephone Company's accounts for 1890 closed with a surplus of £841. 12s. 5d, as against £573. 16s. 4d. for the previous year. The accounts for the past year are now in course of preparation.

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The branches worked directly by the Company maintain their revenues, and in one or two instances slightly show improved results.

The shareholders will remember that last year they approved a resolution to alter the Company's Memorandum of Association so as to embrace "any business or manufacture relating to the generation, employment, or utilisation of electricity or magnetism or the apparatus connected therewith." This resolution having been duly confirmed, application was made to the Court for permission to amend the Company's Memorandum accordingly. The application was, after consideration, sanctioned, but the Court suggested that as the power of extension of business was considerable, the name of the Company should be altered, and expressed approval of its being changed to the "ORIENTAL TELEPHONE AND ELECTRIC COMPANY (LIMITED)."

The Directors see no objection to such alteration, and the following resolution will therefore be submitted for the consideration of the meeting:—

"*That the name of the Company be changed to 'The Oriental Telephone and Electric Company (Limited).'*"

Should the above resolution be passed by the requisite majority, it will be submitted for confirmation as a special resolution to an extraordinary general meeting, which will be subsequently convened.

The Directors to retire at the present meeting are Messrs. Henry Grewing and William Addison, both of whom being eligible, offer themselves for re-election. The auditors of the Company, Messrs. Deloitte, Dever, Griffiths and Co., also retire, and offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 302-322, *&c., &c.*]

CORLETT ELECTRICAL ENGINEERING COMPANY (LIMITED).—This Company was registered on April 7, 1892, with a capital of £10,000, in £10 shares, by Charles Doubble, 14, Serjeants' Inn, Temple, E.C. The objects are to acquire the business of an electrical engineer now carried on by George Stephen Corlett, at Wigan and Bolton, in the county of Lancaster and elsewhere, and the whole or any of the real and personal estate belonging to the said G. S. Corlett in connection with the said business; to carry on the business of electric lighting in all its branches, and in particular to construct, lay down, establish, fix and carry out all necessary cables, wires, lines, accumulators, lamps and works; and to carry on the business of manufacturers of, and to buy, sell, hire, let and deal in dynamos, engines, boilers, lamps, wires, cables, insulating materials, telephones, bells and other apparatus required for, or capable of, being used in connection with the generation, distribution, supply, and accumulation of electricity. The subscribers are:—

	Shares.
G. Stephen Corlett, Wigan, electrical engineer	1
T. D. G. Drayton, Newton-le-Willows, Lancs., colliery proprietor	1
C. Gidlow Jackson, Anderton Hall, Lancs., colliery proprietor	1
W. Johnson, Harewood, Roe-lane, Southport, Lancs., mining engineer	1
J. Brown, 23, Oxford-road, Birkdale, Lancs., cotton spinner	1
W. H. Hewlett, Wigan, coal owner	1
T. Radcliffe Ellis, The Hollies, Wigan, solicitor	1

The number of Directors is not to be less than three nor more than seven, the names of the first to be determined by the subscribers; qualification, £300.

HOLLIDAY AND WILLIAMS (LIMITED).—This Company was registered on April 8, 1892, with a capital of £3,000, in £5 shares. The objects are to carry on the business of general stamped brassfounders, ironfounders, electricians, mechanical and electrical engineers, dealers in engines, tools, implements and appliances, smelters, &c.

THOMAS C. STEEDMAN (LIMITED).—This Company was registered on the 8th inst., with a capital of £5,000, in £1 shares, to carry on the business of importers and manufacturers of and dealers in electrical, chemical, photographical, surgical, and scientific apparatus and materials.

MISCELLANEOUS.—JOSEPH TINN (Limited). Capital, £200,000. Objects: To manufacture black and galvanised iron and steel sheets, rollers of bar, sheet, rail, and other iron, engineers, &c., at the Ashton Iron Rolling Mills, Long Ashton, Bristol, &c.—HENRY BESSEMER and Co. (Limited). Capital, £200,000. Objects: To take over the undertaking of Henry Bessemer and Co. (Limited), in liquidation, to carry on the business of engine and boiler makers, engineers, machine makers, &c.—DISTRICT CHEMICAL COMPANY (Limited), Capital, £50,000. Objects: To manufacture and deal in chemicals, and to acquire inventions or improvements for approved processes for the manufacture of chemicals and the products of chemical processes, &c.

ELECTRIC WIRINGS AND FITTINGS COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 14, 1892, was filed on the 22nd following. The Company was registered on September 11, 1889, with a capital of £5,000, in £1 shares. At the time of making-up, 1,382 shares were taken up, on all of which the full amount had been called. The calls paid amount to £1,375 and unpaid to £7. At the date of the last return, 1,500 shares had been issued as fully paid to Latimer Clark, Muirhead and Co. (Limited), of 23, Regency-street, S.W.; but these by an agreement made November 24, 1890, between Messrs. Latimer Clark of the one part, and the Company of the other part, were cancelled.

ELMORE'S FOREIGN AND COLONIAL PATENT COPPER DEPOSITING COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 12, 1891 (being the fourteenth day succeeding the date of the first ordinary general meeting in 1891), was filed on March 16th last. The reason for the delay is given in a letter of March 1, 1892, from the Secretary, stating that as they had filed a return in January, 1891 (which was, however, for 1890), and as they held their ordinary general meeting on January 29, 1891, it was understood that a return would not be required for the short interval between January 12th and the 29th. At the time of making-up, all the shares had been taken up, of which 6,000 founders' shares had been issued as fully paid. Upon the remaining 3,000 founders' and the 15,000 priority shares, the full amounts have been called, and all calls have been paid. £20 has been paid on 20 priority and 20 founders' shares forfeited. The principal shareholders are Sir Thomas H. Farrer, of Dorking (1,000), F. L. Rawson (5 priority and 1,458 founders'), J. Jepson Atkinson (999 priority and 550 founders'), J. T. Cooper (1,000 priority and 550 founders'), Woodhouse and Rawson United, Limited, of 88, Queen Victoria-street (1348 founders'), James Andrew (567 founders') W. C. Cogalet, of Dorking (deceased), (443 priority and 565 founders'), Francis E. and Alex. S. Elmore, of Spring Grove, Leeds (450 founders' each).

FAREHAM ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 24th, was filed on March 29, 1892. An agreement made on January 15, 1891, between the above Company of the one part and the Laing, Wharton, and Down Construction Syndicate (Limited), determined that certain plant and machinery for the lighting of Fareham by electricity should be sold by the Syndicate to the Company; and in full consideration 1,950 fully-paid ordinary shares, numbered 2,139 to 4,088, both inclusive, should be allotted to the Syndicate or its nominees. According to the return just filed, at the time of making-up, 4,158 shares were taken up, and the full amount called, resulting in the payment of £4,154, and leaving £4 in arrears (making no allowance, however, for the shares issued as fully paid, in accordance with the above agreement).

FOREIGN PILSEN ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 15, 1892, was filed on March 17th following. The Company was registered on January 20, 1885, with a capital of £30,000, in £1 shares, to assume the liabilities, take over as a going concern, and to carry on all or any of the business of the Union Electric Light and Power Company (Limited). At the time of making-up 29,800 shares had been taken up, all of which had been issued as fully paid.

ISLE OF WIGHT ELECTRIC LIGHTING COMPANY (LIMITED).—The statutory return of this Company, made up to April 7th, was filed on the following day. The Company was registered on November 12th last, with a capital of £1,000, in £1 shares. By special resolution, passed December 3, 1891, confirmed December 18, 1891, the capital of the Company was divided into 940 ordinary, and 60 founders' shares. At the time of making-up, 7 shares had been taken up, upon which no calls had been paid, the original subscribers being the only shareholders. No agreements of any kind have been filed.

MINERS' LAMP ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 1, 1892, was filed on March 29th. This is really the return for 1891, February 1, 1892, being the fourteenth day succeeding the date of the first ordinary general meeting in 1891, which was held on November 18, 1891; then, by adjournment, on December 16, 1891; and then, by further adjournment, on January 18, 1892. The Company was registered on January 12, 1889, with a capital of £3,000, in £5 shares. At the time of making-up, 301 shares had been taken up, of which 180 had been issued as fully paid. Upon the remainder the full amount had been called, resulting in the payment of £550, and leaving £5 in arrears.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—In our advertisement pages will be found particulars of the sixth drawing of Five per Cent. Debentures (1884 issue), which will be paid off at par on July 30th next, at the Alliance Bank, Bartholomew-lane, London, E.C., and the interest thereon will cease after July 31st. 168 debentures of £100 each have been drawn.

CALLS DUE.—£5 on INDIA RUBBER, GUTTA PERCHA AND TELEGRAPH WORKS COMPANY, LIMITED (*April 14*); £25 (final) on NATIONAL TELEPHONE COMPANY, LIMITED (*April 21*).

CARBON ELECTRIC (LIMITED).—At an extraordinary general meeting of the members of this Company, held at the Company's offices, 33, Old Broad-street, London, E.C., on February 17th last, the following special resolution was passed, and at a subsequent extraordinary general meeting on March 5, was confirmed:—"Resolved, that the Memorandum of Association of this Company, clause 5, be amended by dividing the capital of the Company into 2,100 Preference shares of £5 each and 1,900 Deferred shares of £5 each, in place of the present division of the capital of the Company."

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended April 10th were £742, as against £830 for the corresponding period of last year, being a decrease of £88. The total receipts to date, from January 1st last, amount to £12,083, against £10,914 in the corresponding period of 1891, being an increase of £1,169.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—An interim dividend of 3s. 6d. per share, free of income-tax (which is at the rate of

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3½ per cent. per annum), for the quarter ending 31st March, has been declared by this Company. The dividend will be payable on and after the 23rd instant.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment by warrants, on May 2nd next, of interest for the half year ending April 30th on their Four per Cent. Mortgage Debenture Stock. The transfer books will be closed from April 27th to May 2nd, both days inclusive.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LTD.).—Mr. Emile Garcke, formerly Managing Director of the Brush Electrical Engineering Company, Limited, has been appointed Managing Director of the Electric and General Investment Company, Limited.

MANITOBA ELECTRIC AND GAS LIGHT COMPANY (LIMITED).—A special meeting of the debenture holders of this Company was held at 31 Lombard-street, on Monday last, to enable one of the trustees for the debenture holders (Mr. Lionel R. C. Boyle) to resign his position.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—The electric current sold by this Company during the quarter ending March 31st last amounted to £10,024, as against £9,652 for the corresponding period of last year.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ending April 8, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,052.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price April 6.		Price Tuesday, April 12.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending April 12.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	16/0	Anglo-American	49½	50½	49½	50½	4 19 0	Jan., Apr., July, Oct.	49½	..
£2,849,510	Stock	3 1/0	Do. Preferred	88½	89½	88½	89½	5 17 4	" "	89½	89
£2,849,510	Stock	5/0	Do. Deferred	11½	12	11½	11⅝	..	" "	11⅝	11⅜
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	102½	101½
130,000	£10	3/0	Brazilian Submarine	10¾	11½	10¾	11½	7 2 3	Mar., June, Oct., Dec.	11¼	11
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	155	160	155	160	4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	10½	11½	10½	11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½	3⅝	3½	3⅝	6 18 8	April and October	..	..
6,000	5	10%	Do. Preference 10%	8½	9½	8½	9½	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11½	12½	11½	12½	5 12 0	Jan., Apr., July, Oct	11½	11¼
400,000	10	2/6	Eastern	14¾	15	14¾	15	4 3 4	" "	15	14 13/16
70,000	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15½	15⅝	3 16 2	" "	15 5/8	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	109	112	109	112	3 11 5	May and November	111	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅝	15½	15	15¼	4 11 10	Jan., Apr., July, Oct.	15 3/16	14 13/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	107	110	108	111	3 12 1	February & August	108½	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102	105	102	105	4 15 3	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb..1900	101	104	102	105	4 15 3	" "	102½	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99	102	99	102	3 18 5	February & August	101½	101⅓
180,227	10	1/6	Globe Telegraph and Trust	10	10½	10⅜	10⅝	5 1 2	Jan., Apr., July, Oct.	10 5/16	10⅜
180,042	10	6%	Do. 6 per Cent. Preference	15	15½	15⅜	15⅝	3 18 1	" "	15½	15 5/16
150,000	10	5/0	Great Northern	18¾	19¼	18¾	19¼	4 8 4	Jan., April, and July	19	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 3	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	7	8	6	7	5 14 3	April and October	7	..
3,381	£100 Cert.	6%	Submarine Cables Trust 6%	116	121	116	121	4 19 2	" "	..	..
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	101	..
30,000	10	2/0	West Coast of America	3½	4¼	3½	4½	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	..	..
88,321	10	1/0	West India and Panama	1⅝	1⅞	1⅝	1⅞	..	" "	1 13/16	1 11/16
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10¼	5 14 3	May and November	10½	10¼
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8½	9½	9	10	6 0 0	" "	9	..
67,007	15	6/0	Western and Brazilian	10	10⅛	10	10¼	7 2 10	" "	10 5/16	10
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 3	" "	6⅝	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4	4½	4	4½	..	" "	4½	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104	107	104	107	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	104	107	104	107	5 12 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	97	100	97	100	6 0 0	March & September	..	..
			TELEPHONES.								
124,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	3/8	¼	3/8	¼	8 7 7	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	¼	3/8	¼	3/8	6 8 11	Yearly	..	..
438,984	5	2/6	National	4⅜	4⅝	4¼	4½	6 13 4	June and December	4 5/16	4 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13½	12½	13½	4 8 11	" "	13½	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	11½	12½	12	12½	4 16 0	" "	12 5/16	12½
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	106	108	106	108	4 3 4	January and July	107	106½
58,000	5	1/0	United River Plate	2	3	2	3	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£8 paid)	7½	8	7½	8	..	—	7½	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	..	..
8,332	£5	..	House to House Electric	..	..	..	..	..	—	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	..	..	5½	6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	5½	6	..	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 paid)	2⅞	3	2⅞	3	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5	5½	5	5½	..	March	..	..
111,000	5	..	London Electric Supply	¾	1	¾	1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8¼	8⅞	8¼	8⅝	..	..	8⅝	8½
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4	4½	4	5	..	..	4⅝	..
18,680	£5	5/0	St. James' and Pall Mall	8½	8⅝	8½	8⅝	—	..	8⅝	8½
7,900	£5	7%	Do. 7% Preference	7½	7⅝	7½	8	..	..	7 13/16	7 11/16
42,563	5	..	Westminster Electric Supply (fully paid)	6½	6⅞	6½	7	..	..	6⅝	..
			ELECTRIC MANUFACTURING, &c., COMPANIES								
77,978	3	1/9	Brush Electrical Engineering	3	3¼	3	3¼	..	..	3¼	3 1/16
69,996	2	6%	Do. 6 per Cent. Preference	2	2¼	2	2¼	5 2 7	..	2¼	2 1/16
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼	6	5¼	5¾	5 16 8	January and July	..	..
17,139	5	17½	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	5⅜	6¼	5⅜	6¼	..	—	6 1/16	5⅜
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜	2⅝	2⅜	2⅝	..	—	2⅝	..
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	20	21	19½	20½	4 17 7	February & August	20½	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	105	102	105	4 5 9	March & September	103¾	..
11,334	£10	6/4	International Okonite Limited Ordinary	4	5	4½	5½	..	..	..	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	3/8	½	6/0	8/0	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	3¾	4¼	3¾	4¼	9 0 9	May and November	4 1/16	4
36,250	12	36/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 1	March and July	43⅜	42½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July	..	..
..	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	..	..	..	..	4 10 0	..	..	..
—	£5	8%	Do. Preference (fully paid)	..	..	..	..	11 0 0	..	..	..
			RAILWAYS AND TRAMWAYS.								
£2,850	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
60,000	£10	—	City and South London Railway	2½	3½	2½	3½	..	—	..	..

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Electric Communication between Lightships and the Shore.—In response to a requisition, signed amongst others by Mr. Henry T. Foster (Sheriff of London), Sir A. K. Rollit, M.P., Mr. James Lowther, M.P., M. E. Sève (Consul General of Belgium), and the mayors of the boroughs on the south coast, a meeting is to be held at the Mansion House, on the 26th inst., under the auspices of the National Sea Fisheries Protection Association, in support of the resolution to be moved in the House of Commons, by Sir Edward Birkbeck, urging the Government to take steps to establish electric communication between lightships, lighthouses, and the shore, for the saving of life and property at sea.

Self-Governing "Pelton" Water Wheel.—The Pelton Water Company, of San Francisco, have recently brought out a governor. The motor, says *Industries*, is provided with a throttle valve and centrifugal governor to regulate the speed under varying loads. The centrifugal governor is mounted on a spindle having two bevelled friction pinions, which make contact alternately with a larger friction disc, thereby moving it either to the right or left according to the speed of rotation. On the spindle carrying the large friction disc is a worm, which gears with a worm-wheel fixed on the same spindle as a small-toothed pinion. The latter, in turn, gears with a large-toothed sector, which is mounted upon a spindle carrying a winged valve, thereby enabling the adjustment of the valve and the regulation of the water.

Magnetite.—According to some investigations of Holz, magnetite can attain a permanent magnetisation 1½ times that attained by steel, even in strong fields. In a recent number of *Wiedemann's Annalen* Anton Abt gives the results of some experiments of his own on two samples of magnetite from the beds of Moravicza (Hungary). One piece was pure, but somewhat porous; the other was dense, fine-grained, and traversed by yellow veins composed of chalcopyrite, which had mostly been transformed into malachite. Two parallelepipeds were cut out and compared magnetically with similar sized pieces of tempered steel, reheated to blue. Holz's results were generally confirmed. The permanent magnetisation of magnetite was found to be greater than that of steel, but the temporary magnetisation and its retentivity in face of a demagnetising force were less.

The Incandescent Lighting of the Chicago Exhibition.—The tenders (nine in number) for furnishing the incandescent lights at the Chicago Exhibition were opened on April 2nd. In all about 85,000 lamps were enumerated. Some of the tenders were for the entire installation. The Thomson-Houston Company's figure was $14.51 per lamp for dynamos and auxiliary apparatus, and from $3 to $4 extra per lamp with inside wiring complete. The Edison Company's figures were respectively $14.16 and $18.49 per lamp. The seven other companies which sent in tenders were the Brush Company, the Fort-Wayne Company, the Electrical Construction Company (Chicago), the Mather Electric Company, the Western Electric Company, the Heisler Electric Company, the South Side Machine and Metal Works (Chicago). No action, says the *Western Electrician* of April 9th, has as yet been taken by the Committee.

An Artificial Aurora.—An experiment showing "molecular bombardment" and the "aurora" may be made, says Mr. T. B. Heimstreet in the *Electrical World*, by rubbing an incandescent lamp on the clothing, or on paper, leather, sheet rubber or tin foil, when the bulb will become filled with light; if you stop it grows dark. If touched with the finger the filament and the interior will be a bright glow lasting from one to three seconds; if touched again it is repeated; by drumming or drawing the finger slowly over the glass the light is quite continuous. If rubbed on newspaper in an absolutely dark room, the larger letters can be read at a distance of two or three inches. Fan the bulb with sheet rubber eight or ten inches away, but do not touch the glass, it will light the same quite bright if the fanning is very rapid. The lamps used were the Edison 16 c.p., 20 and 22 volts. Most of the miniature lamps will give the light, but not all; the 110-volt store lamps will not.

The Chicago Exhibition.—A meeting was held in the Manchester Town Hall on the 8th inst. to hear addresses from Mr. McCormick, the Commissioner from Chicago, Sir Philip Cunliffe Owen, Sir Henry Trueman Wood, and Sir Douglas Galton. Each of these gentlemen explained at length the reasons why they thought that Manchester manufacturers and merchants should exhibit at Chicago; and Mr. McCormick dwelt upon the efforts which were being made by the United States to extend its trade, and to the volume of trade done with England. Mr. Alderman Bailey said he did not know any engineers in this district who proposed to exhibit. He thought that the effect of sending exhibits would only be to have them copied, and he proposed to make a special journey in order to see for himself what was being done. There was a general feeling, says *Industries*, that this was the right view to take, and it is very improbable that any extensive engineering exhibits will go from the Manchester district.

The Exhibition of the Société Française de Physique.—The annual exhibition of the Société Française de Physique was held on the 19th, 20th, and 21st, in the building of the Société d'Encouragement. Among the more noteworthy events, says our Paris correspondent, were a repetition by M. d'Arsonval of the Tesla and of the Elihu Thomson experiments. The experiments were very successful, and many were of a novel character. M. d'Arsonval made a great point of showing the difference in the physiological effects of alternating currents of different kinds. M. P. Janet showed an apparatus for the stroboscopic study of alternating currents. MM. Richard Frères showed an electric kinemograph, and an hydraulic dynamometer, which had been used in determining the variation of tractive effort with the speed of a vessel. The same firm also showed a Deprez d'Arsonval galvanometer which registered photographically. M. Ducret showed some apparatus constructed for the carrying out experiments with polyphase currents, and M. Besson exhibited a small plant arranged to enable accumulators to be charged by means of the Giraud thermo-electric stove.

Electricity in Queensland.—The first town in Queensland to instal the electric light is Thargomindah, about 1,000 miles from Brisbane. The plant is being installed by Messrs. Trackson Brothers of Brisbane, to the order of a Mr. Patterson. The price of kerosene oil at Thargomindah averages about £1 per tin; gas is out of the question, as the cost of coal carriage would be something like £10 per ton. There is a splendid supply of water at Thargomindah, and an abundance of wood. Great efforts are being made in Queensland to push the telpher system, the colony being particularly favourable to it. The country is so immense that it is impossible as yet to lay down a sufficient mileage of even the lightest railways with any hope of their paying. The idea in using the telpher system is that it should serve as a feeder to the few railways that exist. On the sugar plantations the introduction of the telpher system is viewed with considerable favour, as it would be an ideal way of conveying the cane over long distances. Messrs. Trackson Brothers have just received an order from the Government for the supply of all the electric light fittings for the new wing of the Parliament House, the chief condition being that all the fittings shall be manufactured in the colony.

A Simple Method of Obtaining a Rotary Field.—In the *Electrical World* of April 9th Mr. W. S. Horry describes a simple method of obtaining a rotating magnetic field for experimental purposes from the mains of an ordinary alternating current company. He points out that in an ordinary transformer when loaded the primary and secondary currents are almost exactly opposite. When, however, a 20-light transformer has but one light burning on the secondary circuit, the phase difference between the two currents is substantially 90deg. We have then, says Mr. Horry, in this second case a very practical means for producing a phase difference that can be made to cause rotating magnetism in an iron ring. All that is necessary is to wind the ring with two wires so that there are two vertical and two horizontal poles, and to connect one in series with the primary and the other in series with the secondary circuit of an underloaded transformer. The transformer in this condition

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will give off two currents, which can be of the same strength, and both differing as regards phase. If an iron disc be inserted in the centre of the ring and be left free it will revolve. It is necessary in a motor of this type to have the phases as nearly in quadrature as possible, otherwise we get opposing forces, one tending to pull the armature round and another less powerful force tending to stop it. The efficiency of a motor constructed in this way is unimportant. The desire is simply to call attention to the way in which a very workable current splitter can be made that will produce a rotary magnetic field from simple alternating currents.

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Replacing field magnet-coils	8	19	0
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Total repairs	£41	4	0

The first of the above items was due to the burning out of the insulation on the magnet-coils, the second from the bursting of the binding-wires on the armature, and the last from the wear between the commutators and the copper brushes originally employed. Recently the latter have been replaced by others of carbon, and since the change the motors have run without shaking, and the wear in the commutators is inappreciable. In the latter part of 1889 the company, which had previously been supplied with power from the Roaring Fork Electric Light and Power Company, erected its own generating plant. This has a capacity of 100 electrical H.P., produced by two 50 H.P. Thomson-Houston motor-type dynamos wound for a constant potential of 500 volts, each of which is driven by two Pelton water-wheels 42in. in diameter paired on the same shaft. A head of 80ft. of water, giving a pressure of about 35lb. per square inch at the foot of the main pipe, is obtained by a lander about 1,600ft. long, having a capacity of 1,000 cubic feet of water per minute. The speed of the wheels can be varied according to the requirements of the power by altering the direction of the impinging jets, for which purpose the delivery nozzles are mounted on a ball-and-socket joint, which is connected by a link-motion with a Woodward governor set to maintain a constant speed of the driving-shaft of the wheel. The cost of generating, excluding interest and depreciation, as obtained by dividing the cost of labour and lubricants by the power demanded, is at present about ⅓d. per H.P. per hour, which could be furnished at a lower rate if more power were required. The 7½ H.P. hoist at one of the inclines has lately been replaced by a larger one of 25 H.P., geared so as to raise a load of 3,000lb. on an incline of 60deg. 275ft. per minute. In addition to the hoists an electrically-driven diamond prospecting drill has been in use since July, 1890. About 4,400 linear feet have been bored in twelve months at the rate of 1½ to 2in. per minute, or from 6 to 32ft. in the shift of eight hours, allowing for all delays, the average being about 15ft. per shift. The cost, including all expenses, has been 28s. 8d. per foot, or rather higher than was estimated, but it is thought that this price can be reduced. The full abstract of this Paper, from which these extracts were taken, is printed in the *Foreign Abstracts* of the Institution of Civil Engineers.

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TRANSFORMER PREDETERMINATIONS.*

BY DR. J. A. FLEMING, M.A.

When an alternating E.M.F. is applied to the primary terminals of a transformer with open secondary circuit, or to the terminals of a simple choking coil, a small current is found to flow through the circuit, which is commonly, but rather erroneously, called the "magnetising current." It would be better to call this the "core' current, because its magnitude is very largely dependent upon actions taking place in the iron core. If a given conducting circuit, say an insulated copper wire, is wound on a bobbin non-inductively, and a certain alternating electromotive force applied to the ends of the circuit, it is a very easy matter to calculate the ampere value of the current, which will under these circumstances flow through the circuit. For the $\sqrt{\text{mean}^2}$† value of the current is at once obtained by dividing the $\sqrt{\text{mean}^2}$ value of the electromotive force by the ohmic resistance (R) of the wire. Again, suppose that this same circuit is wound inductively on a non-magnetic and non-conducting core or bobbin, the circuit has then a definite inductance (L), and the $\sqrt{\text{mean}^2}$ value of the current is obtained by dividing the $\sqrt{\text{mean}^2}$ value of the electromotive force by the impedance ($\sqrt{R^2 + p^2 L^2}$) of the circuit. In both these cases the energy supplied to the circuit is simply dissipated in the form of heat in the copper circuit. If, however, we suppose the copper circuit to be wound inductively on a magnetisable core, the problem of predetermining the current is not quite so simple. If the core is an ordinary iron core, then the energy supplied to the circuit is taken up in three ways—(i.) it is partly dissipated as heat in the copper circuit; (ii.) it is further dissipated by true magnetic hysteresis waste in the iron core; and (iii.) it is also wasted by reason of eddy currents set up in the core. A little reflection will show that the final result of both hysteresis and eddy current waste is equivalent, as far as energy waste is concerned, to closing a secondary circuit round an ideal non-hysteretic and non-conducting core. For we may imagine that the energy waste due to all the little eddy currents in the core and that due to the magnetic reversals to be imitated by simple resistance waste of a secondary current of a certain magnitude flowing in a closed secondary circuit wrapped round a perfectly ideal iron core in which these wastes do not go on. Now the effect of the secondary circuit, when closed, is to advance the phase of the primary current, and to increase its mean value. Hence, we may conclude that the total effect of the eddy currents and the hysteresis losses in an iron core upon the phase and magnitude of the so-called magnetising current is to increase its magnitude, and to bring it more into consonance with the impressed electromotive force as far as phase is concerned.

This action introduces further difficulties into the problem of predetermining the magnetising current of a transformer, or the current flowing through a choking coil when subjected to a certain alternating electromotive force of determined magnitude and frequency.

The general solution of this problem is a rather difficult matter; but we shall see that fortunately it may be easily solved for the cases most likely to occur in practice.

For the moment let us suppose ourselves dealing with a core in which both eddy current and hysteresis waste are so small as to be negligible, and consider, under these circumstances, how the magnitude of the current flowing through the primary circuit when the secondary circuit is open is to be determined.

Let R be the true resistance of the primary circuit, e the instantaneous value at any time of the impressed electromotive force acting on this circuit, and let i be the value of the current flowing through the circuit at that same instant. Also, let S be the cross-section of the magnetic circuit or of the core, and l be its mean length, and N the number of turns of the primary current round the core, and n the frequency of the alternations. Let b be the value of the induction density in the core at the instant of time considered.

We shall suppose the electromotive force to be a simple periodic function of the time, as usual, so that,

$$e = \mathrm{E} \sin p\,t.$$

If, then, μ is the value of the true magnetic permeability of the core at the instant when the induction density is b, the relation between i and b will be expressed by the equation,

$$4\pi \frac{\mathrm{N}}{l} \mu i = b \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

If instead of measuring i and b in C.-G.-S. or absolute units we measure i in amperes and b in gausses* per square centimetre then equation (1) becomes,

$$\frac{4\pi}{10^9} \frac{\mathrm{N}}{l} \mu i = b \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

These equations immediately follow from the facts that the magnetic force in the interior of a closed solenoid is by a fundamental principle equal in magnitude to 4π-times the absolute current turns per unit of length of the solenoid, and also that the quotient of induction density by permeability is a measure of the magnetic force in the interior of the core. From (2) it immediately follows that,

$$\frac{4\pi}{10^9} \frac{\mathrm{S\,N^2}}{l} \mu i = \mathrm{S\,N}\, b \quad . \quad . \quad . \quad . \quad . \quad (3);$$

and that

$$\frac{4\pi}{10^9} \frac{\mathrm{S\,N^2}}{l} \mu \frac{di}{dt} = \mathrm{S\,N} \frac{db}{dt} \quad . \quad . \quad . \quad . \quad (4).$$

Again, since e is the instantaneous value of the impressed electromotive force it follows that at every instant

$$e = \mathrm{R}\,i + \mathrm{S\,N} \frac{db}{dt} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5).$$

If the resistance of the copper circuit is very small then in practice it will nearly always happen that the magnitude of the resultant electromotive force, R i, is very small compared with the electromotive force of self-induction, viz, $\mathrm{S\,N} \frac{db}{dt}$. This will always be the case if the number of turns, N, of the wire wrapped in the core is considerable. Hence in general we may write (5)

$$e = \mathrm{S\,N} \frac{db}{dt}.$$

Hence from equation (4) it follows that

$$e = \frac{4\pi}{10^9} \frac{\mathrm{S\,N^2}}{l} \mu \frac{di}{dt};$$

but since $e = \mathrm{E} \sin p\,t$ we have

$$i = \frac{10^9\, l\, \mathrm{E}}{4\pi\, \mathrm{S\,N^2}\, \mu} \int \sin p\,t\, dt \quad . \quad . \quad . \quad . \quad (6);$$

and hence the maximum value of i, which we may write I, is given by the equation,

$$\mathrm{I} = \frac{10^9\, l\, \mathrm{E}}{8\pi^2\, \mathrm{S\,N^2}\, n\, \mu} \quad . \quad . \quad . \quad . \quad . \quad (7).$$

Before we can make any use of the above formula (7) we must have some notion of the value to be given to μ in the equation. It may be useful to put down here the values of μ obtained by Prof. Ewing for a very long, soft, and well-annealed iron wire, corresponding to certain values of the induction density in the wire. They are as follows:—

Lines of force per square centimetre. The induction density (B) in C.-G.-S. measure.	Corresponding value of the permeability (μ) for good soft wrought iron.
1,000	560
2,000	880
3 000	1,160
4,000	1,400
5,000	1,600
6,000	1,800
7,000	1,960
8,000	2,120
9,000	2,280
10,000	2,350

* These articles form part of Vol. II. of "The Alternate Current Transformer in Theory and Practice." All rights reserved.

† The symbol $\sqrt{\text{mean}^2}$ stands for the expression "the square root of the mean of the squares of the equidistant instantaneous values of the current or E.M.F. during the phase." The $\sqrt{\text{mean}^2}$ current is commonly called the *effective* or *virtual current*.

* One gauss is a unit of magnetic induction equal to 10^8 "lines of force," or C.-G.-S. units.

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will give off two currents, which can be of the same strength, and both differing as regards phase. If an iron disc be inserted in the centre of the ring and be left free it will revolve. It is necessary in a motor of this type to have the phases as nearly in quadrature as possible, otherwise we get opposing forces, one tending to pull the armature round and another less powerful force tending to stop it. The efficiency of a motor constructed in this way is unimportant. The desire is simply to call attention to the way in which a very workable current splitter can be made that will produce a rotary magnetic field from simple alternating currents.

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Replacing commutators	15	12	0
Total repairs	£41	4	0

The first of the above items was due to the burning out of the insulation on the magnet-coils, the second from the bursting of the binding-wires on the armature, and the last from the wear between the commutators and the copper brushes originally employed. Recently the latter have been replaced by others of carbon, and since the change the motors have run without shaking, and the wear in the commutators is inappreciable. In the latter part of 1889 the company, which had previously been supplied with power from the Roaring Fork Electric Light and Power Company, erected its own generating plant. This has a capacity of 100 electrical H.P., produced by two 50 H.P. Thomson-Houston motor-type dynamos wound for a constant potential of 500 volts, each of which is driven by two Pelton water-wheels 42in. in diameter paired on the same shaft. A head of 80ft. of water, giving a pressure of about 35lb. per square inch at the foot of the main pipe, is obtained by a lander about 1,600ft. long, having a capacity of 1,000 cubic feet of water per minute. The speed of the wheels can be varied according to the requirements of the power by altering the direction of the impinging jets, for which purpose the delivery nozzles are mounted on a ball-and-socket joint, which is connected by a link-motion with a Woodward governor set to maintain a constant speed of the driving-shaft of the wheel. The cost of generating, excluding interest and depreciation, as obtained by dividing the cost of labour and lubricants by the power demanded, is at present about ⅓d. per H.P. per hour, which could be furnished at a lower rate if more power were required. The 7½ H.P. hoist at one of the inclines has lately been replaced by a larger one of 25 H.P., geared so as to raise a load of 3,000lb. on an incline of 60deg. 275ft. per minute. In addition to the hoists an electrically-driven diamond prospecting drill has been in use since July, 1890. About 4,400 linear feet have been bored in twelve months at the rate of 1½ to 2in. per minute, or from 6 to 32ft. in the shift of eight hours, allowing for all delays, the average being about 15ft. per shift. The cost, including all expenses, has been 28s. 8d. per foot, or rather higher than was estimated, but it is thought that this price can be reduced. The full abstract of this Paper, from which these extracts were taken, is printed in the *Foreign Abstracts* of the Institution of Civil Engineers.

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TRANSFORMER PREDETERMINATIONS.*

BY DR. J. A. FLEMING, M.A.

When an alternating E.M.F. is applied to the primary terminals of a transformer with open secondary circuit, or to the terminals of a simple choking coil, a small current is found to flow through the circuit, which is commonly, but rather erroneously, called the "magnetising current." It would be better to call this the "core' current, because its magnitude is very largely dependent upon actions taking place in the iron core. If a given conducting circuit, say an insulated copper wire, is wound on a bobbin non-inductively, and a certain alternating electromotive force applied to the ends of the circuit, it is a very easy matter to calculate the ampere value of the current, which will under these circumstances flow through the circuit. For the $\sqrt{\text{mean}^2}$† value of the current is at once obtained by dividing the $\sqrt{\text{mean}^2}$ value of the electromotive force by the ohmic resistance (R) of the wire. Again, suppose that this same circuit is wound inductively on a non-magnetic and non-conducting core or bobbin, the circuit has then a definite inductance (L), and the $\sqrt{\text{mean}^2}$ value of the current is obtained by dividing the $\sqrt{\text{mean}^2}$ value of the electromotive force by the impedance ($\sqrt{R^2 + p^2 L^2}$) of the circuit. In both these cases the energy supplied to the circuit is simply dissipated in the form of heat in the copper circuit. If, however, we suppose the copper circuit to be wound inductively on a magnetisable core, the problem of predetermining the current is not quite so simple. If the core is an ordinary iron core, then the energy supplied to the circuit is taken up in three ways—(i.) it is partly dissipated as heat in the copper circuit; (ii.) it is further dissipated by true magnetic hysteresis waste in the iron core; and (iii.) it is also wasted by reason of eddy currents set up in the core. A little reflection will show that the final result of both hysteresis and eddy current waste is equivalent, as far as energy waste is concerned, to closing a secondary circuit round an ideal non-hysteretic and non-conducting core. For we may imagine that the energy waste due to all the little eddy currents in the core and that due to the magnetic reversals to be imitated by simple resistance waste of a secondary current of a certain magnitude flowing in a closed secondary circuit wrapped round a perfectly ideal iron core in which these wastes do not go on. Now the effect of the secondary circuit, when closed, is to advance the phase of the primary current, and to increase its mean value. Hence, we may conclude that the total effect of the eddy currents and the hysteresis losses in an iron core upon the phase and magnitude of the so-called magnetising current is to increase its magnitude, and to bring it more into consonance with the impressed electromotive force as far as phase is concerned.

This action introduces further difficulties into the problem of predetermining the magnetising current of a transformer, or the current flowing through a choking coil when subjected to a certain alternating electromotive force of determined magnitude and frequency.

The general solution of this problem is a rather difficult matter; but we shall see that fortunately it may be easily solved for the cases most likely to occur in practice.

For the moment let us suppose ourselves dealing with a core in which both eddy current and hysteresis waste are so small as to be negligible, and consider, under these circumstances, how the magnitude of the current flowing through the primary circuit when the secondary circuit is open is to be determined.

Let R be the true resistance of the primary circuit, e the instantaneous value at any time of the impressed electromotive force acting on this circuit, and let i be the value of the current flowing through the circuit at that same instant. Also, let S be the cross-section of the magnetic circuit or of the core, and l be its mean length, and N the number of turns of the primary current round the core, and n the frequency of the alternations. Let b be the value of the induction density in the core at the instant of time considered.

We shall suppose the electromotive force to be a simple periodic function of the time, as usual, so that,

$$e = \mathrm{E} \sin p\,t.$$

If, then, μ is the value of the true magnetic permeability of the core at the instant when the induction density is b, the relation between i and b will be expressed by the equation,

$$4\pi \frac{\mathrm{N}}{l} \mu i = b \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

If instead of measuring i and b in C.-G.-S. or absolute units we measure i in amperes and b in gausses* per square centimetre then equation (1) becomes,

$$\frac{4\pi}{10^9} \frac{\mathrm{N}}{l} \mu i = b \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

These equations immediately follow from the facts that the magnetic force in the interior of a closed solenoid is by a fundamental principle equal in magnitude to 4π-times the absolute current turns per unit of length of the solenoid, and also that the quotient of induction density by permeability is a measure of the magnetic force in the interior of the core. From (2) it immediately follows that,

$$\frac{4\pi}{10^9} \frac{\mathrm{S\,N^2}}{l} \mu i = \mathrm{S\,N}\, b \quad . \quad . \quad . \quad . \quad . \quad (3);$$

and that

$$\frac{4\pi}{10^9} \frac{\mathrm{S\,N^2}}{l} \mu \frac{di}{dt} = \mathrm{S\,N} \frac{db}{dt} \quad . \quad . \quad . \quad . \quad (4).$$

Again, since e is the instantaneous value of the impressed electromotive force it follows that at every instant

$$e = \mathrm{R}\,i + \mathrm{S\,N} \frac{db}{dt} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5).$$

If the resistance of the copper circuit is very small then in practice it will nearly always happen that the magnitude of the resultant electromotive force, R i, is very small compared with the electromotive force of self-induction, viz, $\mathrm{S\,N} \frac{db}{dt}$. This will always be the case if the number of turns, N, of the wire wrapped in the core is considerable. Hence in general we may write (5)

$$e = \mathrm{S\,N} \frac{db}{dt}.$$

Hence from equation (4) it follows that

$$e = \frac{4\pi}{10^9} \frac{\mathrm{S\,N^2}}{l} \mu \frac{di}{dt};$$

but since $e = \mathrm{E} \sin p\,t$ we have

$$i = \frac{10^9\, l\, \mathrm{E}}{4\pi\, \mathrm{S\,N^2}\, \mu} \int \sin p\,t\, dt \quad . \quad . \quad . \quad . \quad (6);$$

and hence the maximum value of i, which we may write I, is given by the equation,

$$\mathrm{I} = \frac{10^9\, l\, \mathrm{E}}{8\pi^2\, \mathrm{S\,N^2}\, n\, \mu} \quad . \quad . \quad . \quad . \quad . \quad (7).$$

Before we can make any use of the above formula (7) we must have some notion of the value to be given to μ in the equation. It may be useful to put down here the values of μ obtained by Prof. Ewing for a very long, soft, and well-annealed iron wire, corresponding to certain values of the induction density in the wire. They are as follows:—

Lines of force per square centimetre. The induction density (B) in C.-G.-S. measure.	Corresponding value of the permeability (μ) for good soft wrought iron.
1,000	560
2,000	880
3 000	1,160
4,000	1,400
5,000	1,600
6,000	1,800
7,000	1,960
8,000	2,120
9,000	2,280
10,000	2,350

* These articles form part of Vol. II. of "The Alternate Current Transformer in Theory and Practice." All rights reserved.

† The symbol $\sqrt{\text{mean}^2}$ stands for the expression "the square root of the mean of the squares of the equidistant instantaneous values of the current or E.M.F. during the phase." The $\sqrt{\text{mean}^2}$ current is commonly called the *effective* or *virtual current*.

* One gauss is a unit of magnetic induction equal to 10^8 "lines of force," or C.-G.-S. units.

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If we apply the values of μ taken from the above table in conjunction with the equation (7) to calculate the maximum value of the primary current on open secondary circuit for any transformer of the closed magnetic circuit type, we shall generally, but not always, find that the so calculated value of the current is less than the observed value. In many cases, however, the formula will give us a fair approximation to the maximum value of the so-called magnetising current. Thus, for example, take the case of the small Westinghouse transformer employed in Ryan's experiment and referred to in *The Electrician* of January 22nd. The mean length (l) of the magnetic circuit is 31 centimetres, the cross section (S) 63 square centimetres, and the number of turns (N) of the primary circuit 675. The frequency (n) was 138, and the value of E, 1,400 volts. Insert these values in (7) and we have

$$I = \frac{10^9 \times 31 \times 1400}{8\pi^2 \times 63 \times (675)^2 \times 138 \times \mu} = \frac{139}{\mu} \quad . \quad . \quad (8).$$

The maximum value of the induction density was in this case nearly 4,000. Corresponding to B = 4,000, the static permeability of soft iron is 1,400. If we put $\mu = 1{,}400$ in (8) we have I = ·1 ampere, whereas the maximum value of the primary current on open secondary was 0·21 ampere. The quality of the iron may, however, have been inferior. Moreover, the eddy current and hysteresis loss were in this case considerable. If we give μ the value of 700, then the calculated and observed values of I would agree. An examination of many other cases, however, shows that this equation (7) will give a fair approximation to the observed current.

Thus Mr. Evershed has given* the data of a 30 horse-power Goolden-Ravenshaw Transformer as follows:

Mean length of magnetic circuit	145 cms.
Cross-sectional area of the magnetic circuit	95 sq. cms.
Total volume of iron in core	13,700 c.c.
Frequency	70
Primary turns	680
Secondary turns	34
Primary volts	2,000
Secondary volts	100
Primary circuit resistance	·97 ohm.
Secondary circuit resistance	·003 ohm.
Thickness of core plates	·05 cm.
Full load output	22,400 watts.
Maximum value of the induction density during the cycle	10,000 C.-G.-S. units.
Maximum value of the primary E.M.F.	2,800 volts.

Corresponding to B = 10,000, we have $\mu = 2{,}350$. Hence, substituting the proper values for this transformer in equation (7), we have

$$I = \frac{10^9 \times 145 \times 2800}{8\pi^2 \times 95 \times (680)^2 \times 70 \times 2350} = \cdot 7 \text{ ampere.}$$

Hence the maximum value of the magnetising current is ·7 ampere and the $\sqrt{\text{mean}^2}$ value should be nearly ·5 ampere. The actual value is given as half an ampere. Let us take another instance. The following are the data of a 10 horse-power Ganz Transformer of the closed magnetic circuit type:

Mean length of magnetic circuit		94 cms.
Area of cross section of magnetic circuit		130 sq. cms.
Total volume of iron in core		12,180 c.c.
Weight		95,000 grammes.
Number of primary turns, N_1		1,080
Number of secondary turns, N_2		60
Resistance of primary circuit.....		4·2 ohms.
Resistance of secondary circuit		·0135 ohm.
Total weight of copper in transformer...		40,000 grammes.
Frequency		42·5 ∽
Primary electromotive force	effective value...	1,926 volts.
	maximum value	2,696 volts.
Secondary electromotive force	effective value...	105 volts.
	maximum value	147 volts.
Maximum value of induction density in core.....		7,600 C.-G.-S.
Observed value of the primary currents on open secondary circuit, effective value		·17 ampere.

* See the series of articles on "The Magnetic Circuit of Transformers" in *The Electrician* for February and March, 1891, Vol. XXVI.

Corresponding to a maximum induction of 7,600 C.-G.-S. units the value of the permeability is about 2,000. Hence we should have from the formula the following as a predetermined value for the magnetising currents:—

$$I = \frac{10^9 - 2696}{8\pi^2 - 130 - (1080)^2 - 42{\cdot}5 - 2000} = \cdot 243.$$

Hence the calculated maximum value of the magnetising current is about ·24 ampere, and the effective value or $\sqrt{\text{mean}^2}$ value is ·17 ampere, which exactly agrees with observation.

In the case of a number of other closed circuit transformers, all of which are worked at an induction density of about 4,000 or 5,000 C.-G.-S. which have been examined by the author, the above rule gives a very tolerable approximation to the observed magnetising current. In these cases it was found that by taking values for μ, about 200 less than those given by Ewing for the softest wrought iron, a very close predetermination to the value of the open circuit current could be obtained. The rule must not be, however, applied indiscriminately, and is only valid for cases of closed circuit transformers, having cores of good soft iron well laminated, and for cases in which the magnetisation of the iron is not carried up over the "knee" of the magnetisation curve.

It could not be applied, for instance, in the case of a solid wrought or cast-iron core, for in this case the resulting calculated value of I would be very far below the real or observed value. Such a case is obviously not really that of an open circuit transformer at all, for the eddy currents set up in the core are true secondary currents of considerable magnitude.

The equation (7) may be reduced to another form by expressing the value of μ as a function of B. As the permeability μ varies with the induction B, we may express μ approximately as a function of B, of the form

$$\mu = \alpha \, B^{\beta} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8),$$

where α and β are constants. To find the values to be given to α and β we may proceed thus: Taking logarithms of both sides we have

$$\log \mu = \log \alpha + \beta \log B \quad . \quad . \quad . \quad . \quad . \quad (9).$$

If we plot this curve, taking the values given by Ewing for μ and B, we find that it is approximately a straight line, and that we have very nearly

$$\alpha = 5{\cdot}6, \ \beta = \frac{2}{3},$$

and hence

$$\mu = 5{\cdot}6 \, B^{\frac{2}{3}} \quad . \quad . \quad . \quad . \quad . \quad (10).$$

Calculating by this formula values of μ, and comparing them with the observed, we find a fair general agreement, especially between B = 1,000 and B = 6,000.

B.	Observed value of μ.	Value calculated from equation $\mu = 5{\cdot}6 \, B^{\frac{2}{3}}$.
1,000	560	560
2,000	880	890
3,000	1,160	1,165
4,000	1,400	1,410
5,000	1,600	1,612
6,000	1,800	1,848
7,000	1,960	2,049
8,000	2,120	2,240
9,000	2,280	2,420
10,000	2,350	2,595

From B = 1,000 to B = 5,000 the constant α has exactly the value 5·6, but from 5,000 to 10,000 the observed and calculated values of μ agree better if we take $\alpha = 5{\cdot}3$.

If we take $\alpha = 5$ and $\mu = 5 \, B^{\frac{2}{3}}$, and insert this value of μ in equation (7), we can reduce it to another useful form for practical work.

For taking equation (1), page 653, viz.,

$$4\pi \frac{N}{l} \mu \, i = b \quad . \quad . \quad . \quad . \quad . \quad (11),$$

and putting $\mu = 5 \, b^{\frac{2}{3}}$ we have

$$20\pi \frac{N}{l} i = b^{\frac{1}{3}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (12).$$

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If we put I for the maximum value in amperes of the primary current of the transformer in open secondary circuit, and B for the maximum value of the corresponding maximum induction density in C.-G.-S. measure, and E for the maximum value of the impressed primary electromotive force, then we reduce the equation (12) to the form

$$\frac{44}{7}\frac{N}{l}I = B^{\frac{1}{2}} = (p\,S\,N\,E\,.\,10^8)^{\frac{1}{2}} \quad . \quad . \quad . \quad (13),$$

and this last can be written

$$I = \frac{40\,l}{N}\left(\frac{E}{n\,S\,N}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad (14).$$

From equation (14) we can deduce very approximately the maximum value, I, of the primary "magnetising current" of a transformer when we are given the maximum value E of the primary electromotive force, and the dimension, section S and mean length l of the magnetic circuit, the number of turns N of the primary coil, and the frequency n.

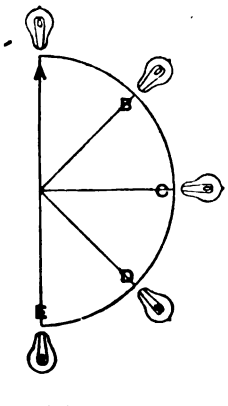
The above equation (14) is, like equation (7), only applicable to closed magnetic circuit transformers with good soft iron cores, well laminated, and in which the ohmic resistance of the wire circuit is insignificant in comparison with the impedance of that circuit. But under these circumstances, when eddy current loss is small, the formula (14) is useful for calculating the open circuit current both for transformers and for choking coils.

(To be continued.)

THE BEST EFFICIENCY FOR INCANDESCENT LAMPS.*

BY ANDRÉ LARNAUDE.

Improvements in the manufacture have brought down the price of the incandescent lamp from 5 francs to less than 2 francs. With regard to the energy expended per unit of light, manufacturers have followed the requirements of consumers, who attach prime importance to the life of the lamps. The question of the use of economical lamps certainly merits the attention of electricians; and if this has



not hitherto been obtained for it, it is probably because central-station managers have been employed in securing the regular working of their stations, or because there is a lack of information. Experiments relating to the life and working conditions of incandescent lamps are very difficult to carry out on account of the precautions which it is necessary to take, and the amount of time required. In spite of improvements in manufacture we have not yet succeeded in turning out lamps having a definite life, and in the same batch of lamps samples are frequently found the life of which varies by 50 per cent. Experiments, therefore, that have any practical value should relate to as many lamps as possible. Some experiments which I carried out in the laboratory of the Compagnie Générale des Lampes Incandescentes related to batches of 50 to 100 lamps taken at random.

In order to imitate, as far as possible the conditions of practice, the lamps were placed in a framework, as shown in the accompanying figure, the lamps being in different position from the point of view of mechanical strain. These experiments showed that the positions B and C were very bad for thin, long filament lamps, such as 10 c.p. lamps taking more than 100 volts.

* From *Le Génie Civil*.

The following table relates to a 16 c.p. 100-volt lamp, taking 3·7 watts to the candle:—

Lamp hours.	Pougies décimales.
0	16·0
200	15·5
400	15·0
600	14·3
800	13·4
1,000	11·5

I am inclined to think that when the amount of light emitted by a lamp has decreased by 15 per cent. below its original value, it should be considered *hors de combat*.

Acting on this basis, we may rely upon the following lives:—

4·0 watts to the candle	1,000 hours.
3·5 " " "	700 "
3·0 " " "	350 "
2·5 " " "	150 "

I will now give a table showing the cost of a 16 c.p. lamp-hour working under various conditions. In order to examine the different cases which occur in practice I have varied the price of the kilowatt hour from 0·25 franc to 1 franc, and have assumed the cost of the lamp to be 2 francs.

Price of kilowatt hour in francs.	Price of the 16-candle lamp-hour.			
	4 watts.	3·5 watts.	3 watts.	2·5 watts.
0·25	0·018	0·017	0·018	0·0235
0·50	0·034	0·031	0·030	0·0335
0·75	0·050	0·045	0·042	0·0135
1·00	0·066	0·059	0·054	0·0535

We see from this table that, even supposing the cost of electricity to be as low as 0·25 franc for the kilowatt hour, it is not advisable to employ a 4-watt lamp. Nevertheless, the small manufacturer, who has cheap power, demands long-lived lamps. I am inclined to think that he is right, and that because of the irregularities which generally occur in the pressure these variations have a more appreciable effect on the life of the lamp, the closer it is running to its most economical figure. Although it is not possible to bring this factor into our calculations it should be taken into account, especially in installations where electricity is obtained at a cheap rate, and in which the cost of the lamp renewals forms a large proportion of the total expense.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-NIGHT) FRIDAY, April 22nd.

INSTITUTION OF CIVIL ENGINEERS.

7.30 p.m. Students' Meeting. Paper to be read: "The Speed and Power of Locomotives." By Edmund L. Hill, Stud.Inst.C.E.

TUESDAY, April 26th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read: "Electric Light Measuring Instruments." By James Swinburne. The meeting will be adjourned at 9:30 p.m., when the President and Council will hold a reception in the Libraries.

WEDNESDAY, April 27th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Egyptian Agriculture." By Prof. Robert Wallace.

THURSDAY, April 28th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Chemistry of Gases." By Prof. Dewar, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Paper to be read: "Notes on the Light of the Electric Arc." By A. P. Trotter, B.A., member. (Illustrated by an experiment.)

FRIDAY, April 29th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Physiology of Dreams." By Dr. B. W. Richardson, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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STEEL-PLATE PORTRAITS

Of W. H. Preece, F.R.S.; Michael Faraday; Sir John Pender, K.C.M.G.; Sir William Thomson, F.R.S. (Past-President of the Institution of Electrical Engineers); C. H. B. Patey, C.B. (Late Secretary of Telegraphs, G.P.O.); Dr. John Hopkinson, F.R.S. (Past-President of the Institution of Electrical Engineers); Dr. Oliver J. Lodge, F.R.S., Prof. William Crookes, F.R.S. (Past-President of the Institution of Electrical Engineers); Willoughby Smith (out of print); Prof. von Helmholtz and Prof. W. E. Ayrton (President of the Institution of Electrical Engineers), have been issued as Supplements to "THE ELECTRICIAN."

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THE TELEGRAPH AND THE ARMY.

Pressure on our space has prevented until now the publication in these pages of Major BERESFORD'S Paper, read before the Royal United Service Institute in the month of February. The subject is of permanent interest, however; and we make no apology for drawing attention to it here, even after this lapse of time. Although entitled "The Telephone at Home and in the Field," Major BERESFORD'S review extended beyond the use of the appliance technically known as the telephone, and of course had a more general reference to electrical signalling on active service. Under this head the telephone can be regarded only as one form of telegraph, or rather as a particular piece of apparatus employed for telegraph signalling. In the service of the Army it matters not in what manner this marvellous little instrument is manipulated, whether by itself as a simple magnetic telephone, or in company of a microphonic transmitter, or even in hybrid conjunction with any of the ordinary telegraph signalling keys. Not being hedged round by any of those proprietorial restrictions which have hindered its free development in the commercial world, the telephone in the Army has free play to show what it is capable of doing in all sorts of circumstances, and under every conceivable condition. Ingenuity and inventiveness have done more for it in the Army probably than anywhere else; and we owe to officers of the Royal Engineers many devices for military telephonic working that will prove welcome to civilian lines whenever they are completely emancipated from the chains of the Patent Office.

It will be seen from the abstract of his Paper which we publish this week that Major BERESFORD has described a

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number of these devices and applications, chiefly relating to the telephone; but as he found himself obliged to make comparisons between systems of which the telephone formed part, and others into which the telephone does not enter at all, yet every one of them useful and even necessary for military purposes, it seems to us that his Paper would have been more correctly described by the title we have ventured to place at the head of this article. Comparisons of the kind we allude to are apt to bring into disrepute any given mode of signalling; for example, the telephone as such, the Morse sounder as such, or the Morse printer, or flag signalling, any one of which may be condemned in given circumstances, but all of them of pre-eminent utility with favourable surroundings. Not only are they useful in themselves, but they can be all efficiently combined; and the electrical series are, moreover, capable of being interchanged or worked the one into the other. A Morse sounder may be worked into a Morse printer, or *vice versâ*, just as either can be worked into a telephone, though unfortunately not in the reverse order. A telephone line, however, in military operations, can dispense with the microphone at one end, and often at both ends. And where there is a break in the continuity of the line, flag-signalling, preferably by the Morse code, may play an important part in filling up the gap.

We have laid some stress on these obvious facts, because of the tendency to extol one mode of signalling to the disparagement of another, and to map out too precisely, as we think Major Beresford has done, the functions of the several systems. We feel sure that all those nice considerations which go to recommend this or that pattern of instrument would be blown to the winds with the first puff of powder, when the chief thought would be how to utilise the apparatus nearest to hand. The gallant lecturer knows this better probably than we do; but he seems to be a little too fastidious, too much the man of peace manœuvres in the matter of insulation with regard to the instrument upon which he is discoursing, when in reality his own branch of the army was the first to demonstrate how superbly superior to insulation that instrument is. For main lines of communication as a talking instrument, the telephone would not be of much service, he says, because it would require double wires "if on the same poles as other lines." But lines of communication are, it may be hoped, sometimes in the enemy's country; and in that case we need hardly provide against "other lines" being left for our use; and we don't suppose that any commanding officer would object to keep up his communications by means of a telephone wire cast on the ground, with no insulation to speak of, and no wires to keep it company, because "it would not carry the traffic we were accustomed to"—meaning, we suppose, officers' telegrams to their friends at home, and the inordinate despatches of importunate special correspondents. It is a relief to learn, in this relation, that we have in the British Army, as in the Belgian and other armies, an appliance by means of which the telephone can be used for speaking purposes over lines worked simultaneously by Morse sounders or printers. Given the sounder or printer, all well and good; what we desire to emphasise is the possibility of dispensing with them, afforded by the simpler, less costly, more mobile, and more sensitive instrument. It should never be forgotten that the telephone will give out intelligible signals, and even audible speech, under conditions which render all other forms of telegraph dumb.

Major Beresford has done more excellent service in pointing out the saving in men which would result from greater completeness of telegraph equipments, including, of course, telephones, than the Army at present can boast of. The work of many men's legs can be spared by the erection of a single line of wire; and he argues further that telegraphic communication with the chief points of an outpost line would reduce the number of men required for outpost duty. From this he proceeds to advise the use of telegraphy in the cavalry service—a branch of Her Majesty's Army which is at present unprovided with this invaluable adjunct of warfare. Here we are led to remark that both as regards the kind of apparatus employed and the regiments to use them, the question is chiefly one of finding competent signallers. It signifies very little indeed what mode of signalling has to be resorted to so long as you can find the right men to do it. More signallers are needed, and under a short-service system the supply has to be continually kept up. We suspect that nothing like the right number or right quality of men are being trained for this highly essential arm of the service. In the last Egyptian war the Post Office rendered invaluable help by lending volunteers who were expert telegraphists and who remained afterwards in the Army Reserve. But these men's time has now probably expired, and their places may have to be filled, perhaps not so easily. Equipment is a most important factor; and by all means get as much of it as a parsimonious country will grant; but of not less importance are the men—men who can turn their hands and ears to anything electrical—without whom all these ingenious and costly appliances will be limited and crippled in their usefulness, and sometimes of no use whatever.

NOTES ON SUBMARINE CABLE WORK.*

BY H. D. WILKINSON.

(*Continued from page 636.*)

8. **Types of Cable.**—While the ship is engaged in picking up it will be well to examine the different types of cable with which we have to deal. If out some distance at sea, it will be the deep-water types of cable we shall meet with, which are the smallest size of any, being only about $\frac{3}{4}$in. diameter. Nearer shore, in depths of from 30 to 250 fathoms, we shall come across a heavier type of cable, about $\frac{7}{8}$ to 1in. diameter; and close in shore, from the landing point to five or ten miles out, we shall find a very large and heavy type of cable known as the shore end, which is specially protected to withstand the constant rolling and friction caused by the tidal wash and being fouled or lifted by ships' anchors. This type is generally in three different sizes, varying from about $1\frac{1}{4}$in. to 2in., or more, in diameter, the largest being used close in shore. Seven leading types of cable as manufactured by the Telegraph Construction and Maintenance Company are represented in Fig. 27, as approximately as possible to actual size.

In all these types the central conductor is a strand of seven copper wires insulated by a coating of gutta-percha, and further protected, outside the percha, by a serving of brass ribbon or tape, to prevent the submarine boring animal, the toredo, from penetrating into the insulation. These minute animals, which exist in the Atlantic Ocean and in eastern seas, and have recently been traced quite close to our shores, settle upon the cable, and after forcing their way in between the sheathing wires, make for the core. The marks on the surface of the percha where the boring has been begun are blotchy and irregular, of about $\frac{1}{8}$in. diameter, but the hole pierced through the percha is less than half this size. Such attacks are frequently made in many places within a length of five miles, making the true position of fault very difficult to locate. The brass sheathing, first introduced by Mr. H. Clifford, engineer to the Telegraph Construction and Maintenance Company, is a most successful preservative against the depredation of these animals. It is necessary to lay an intermediate serving between the gutta-percha and the brass tape, so that the surface of the percha cannot be injured in any way by the metal. Some manufacturers put on a serving of tape over the percha. The

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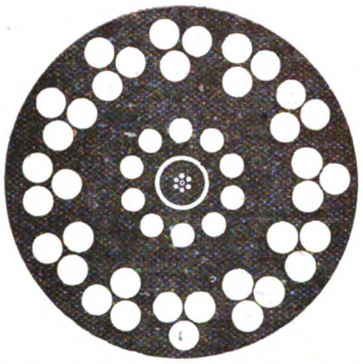
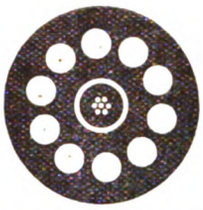
Silvertown Company put on a serving of loose spun linen, composed of 52 separate strands laid together, and so forming a perfectly flat and smooth surface on which to wind the brass tape.

The conductor, taken together with its insulating coating, is technically known as "the core." In the old cables as much as 300 or 400lbs. each of copper and gutta-percha per knot were used in the core; but in modern cables it is more general to use between 100 and 250lbs. The actual and relative weights of copper and gutta-percha used in different parts of the world vary to some extent, and there is some difference also in the practice of different cable companies. In the cables down the west coast of Africa there are, at least, three dimensions of core used with conductors of a fraction over 7, 9, and 11 ohms resistance per knot at standard temperature, and weighing 170, 130, and 107lbs. per knot respectively, while the gutta-percha covering to these cores weighs, respectively, 170, 130, and 140lbs. per knot.

Fig. 27.

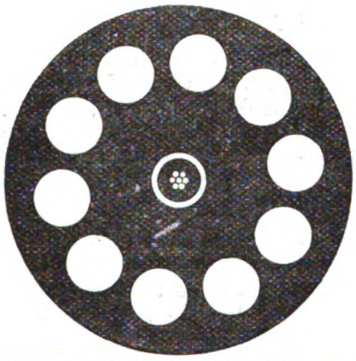


Shore end.—Type AA. (Anchorages to 30 fathoms.)



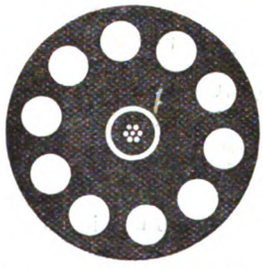
Intermediate.—Type B. (30 to 100 fathoms.)

Intermediate.—Type B'. (100 to 250 fathoms.)

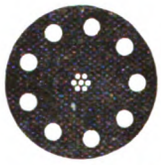


Shore end.—Type A. (To 30 fathoms.)

Deep Sea.—Type D. (200 to 1500 fathoms.)



Shore end.—Type E. (To 60 fathoms.)



Deep Sea.—Type C. (1000 to 3000 fathoms.)

Each complete cable between two places is made up with lengths of shore-end, intermediate and deep-sea types of cable according to the existing depths of water. The heaviest of all is the shore-end type, used for the locality of anchorages. Those portions of harbours in which ships regularly cast anchor are, of course, rigorously avoided where possible in laying. The usual practice is to select a suitable landing place, clear of rocks, and situated a few miles away from the anchorage ground of the port. But where the cable must be landed close to a harbour, a circuitous route is chosen for it until it is out of reach of the general anchorage ground of vessels, and its position is indicated at points along the harbour by red mark-buoys, intelligence to this effect being duly notified to the shipping. The shore end of the Cape cable is laid in this manner round the extreme circuit of Table Bay, the end being landed close to the old jetty at the bottom of the main thoroughfare. But accidents to cables by ships' anchors are more frequent a little distance out of the harbour than in the regular anchorages. Sailing ships tacking into port will cast anchor, if the wind falls, to prevent themselves drifting back with the tide, and it not unfrequently happens that cables are hooked, dragged and raised by these ships, with the result that they are either fractured or so badly fouled and kinked as to cause a dead earth on the line. Most vessels are aware of the fact if they have fouled a cable, whether they have raised it to the surface or not; and some captains report such an occurrence immediately they get in port.

It will be seen from the engraving that the heavy type of shore-end, known as type AA, is protected by an outside sheathing of 12 strands of three wires each, water laid, and an inner sheath of 10 wires. This type is used in harbours near anchorages in depths up to about 30 fathoms, and weighs from 16 to 20 tons per mile. Type A is also a shore-end with a sheathing of 10 wires, and is used in shallow water. Type E is a shore-end for slightly deeper water, up to 60 fathoms, and is protected by 10 sheathing wires. Of the intermediate types two are shown: type B for 30 to 100 fathoms, with 10 sheathing wires, and type B' with 12 smaller sheathing wires, for depths up to 500 fathoms. The deep sea types are type D with 12 small sheathing wires, for depths up to 1,500 fathoms, and type C with nine sheathing wires for the greatest depths known. These weigh only about 2½ tons per mile. The armouring of sheathing wires is designed to give the cable a mechanical strength some three or four times that required to bear its own weight of suspension in the deepest water. Thus, if a cable were to be laid in 2,000 fathoms, it would be made of sufficient tensile strength to support from 6,000 to 8,000 fathoms of its own weight in water, equivalent to a breaking strain of about seven or eight tons per square inch. In order to protect the iron or steel sheathing wires from corrosion, it used to be the practice to cover them with hemp. But on picking up cables so covered, the effects of corrosion are observed to have gone through the hemp and destroyed the fibre, and it is now the general practice to tape each of the wires separately, the tape being sometimes prepared with stearine. The whole is then covered with a compound of gutta-percha and Chatterton's compound (one part each of Stockholm tar and resin, and three parts of gutta-percha).

It may be of interest to show how the above types of cable are distributed on long cables, both in deep and shallow water. As an instance of one, we may cite the cable connecting Cape Town with Mossamedes on the West Coast. Starting from the Cape Town end, this cable consists of the following lengths, spliced together, of the above types:—

6	knots of	type	A	1·5	knots of	type	B
13	,,	,,	E	62·5	,,	,,	B'
41	,,	,,	B	931	,,	,,	D
167·7	,,	,,	B'	2	,,	,,	B
98	,,	,,	D	1	,,	,,	A
58·6	,,	,,	B'	1	,,	,,	AA

The total length being thus a little over 1,383 knots. At a distance of 384 knots from Cape Town a T-piece is jointed to this cable leading to an intermediate station on the coast, and the cable is accordingly strengthened at this point by a short length of type B. The depth in which type D in this cable is laid is about 1,000 fathoms.

As an instance of a shallow-water cable we may take the cable laid along the coast of the Gulf of Guinea, between Accra on the Gold Coast and Sierra Leone. This cable is 1,019 knots in length, and laid in water not more than 720 fathoms in the deepest part, the average depth being about 100 fathoms. The lightest type used in this cable is type B', the different types being spliced together in the following lengths, starting from Sierra Leone:—

5	knots of	type	A	18·4	knots of	type	B
5	,,	,,	E	3	,,	,,	E
46·8	,,	,,	B	2	,,	,,	AA
939	,,	,,	B'				

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These particulars, noted down in the paying-out log at the time the cable is first laid, together with a chart of the course of the cable, are all spread out in the chart-room on board ship at the time of repairs, so that every information about the cable is at hand. The paying-out log is an abstract of each position, or change of course, with calculated distances and lengths of cable paid out, &c. The details recorded in this log are of a series of positions, giving the latitude, longitude, and true course of the vessel at each position during the laying of the cable. The true distances between each position are entered in the log and added together as the ship proceeds, while the actual lengths of cable paid out between each position are also recorded. These respective distances and lengths so added together furnish at once the amount of cable paid out up to any position and the corresponding distance travelled by the ship, the difference between these distances giving the slack. The actual and percentage amount of slack paid out between positions is also recorded, together with these figures for the whole cable. The percentage of slack on cables laid in depths exceeding 1,500 fathoms may amount on the average to 10 per cent. or more, but for average depths the slack is about 6 per cent. The positions of the various splices and the types of cable at the splices are also recorded, and these records are altered according as new splices and lengths of cable are added by subsequent repairs.

(To be continued.)

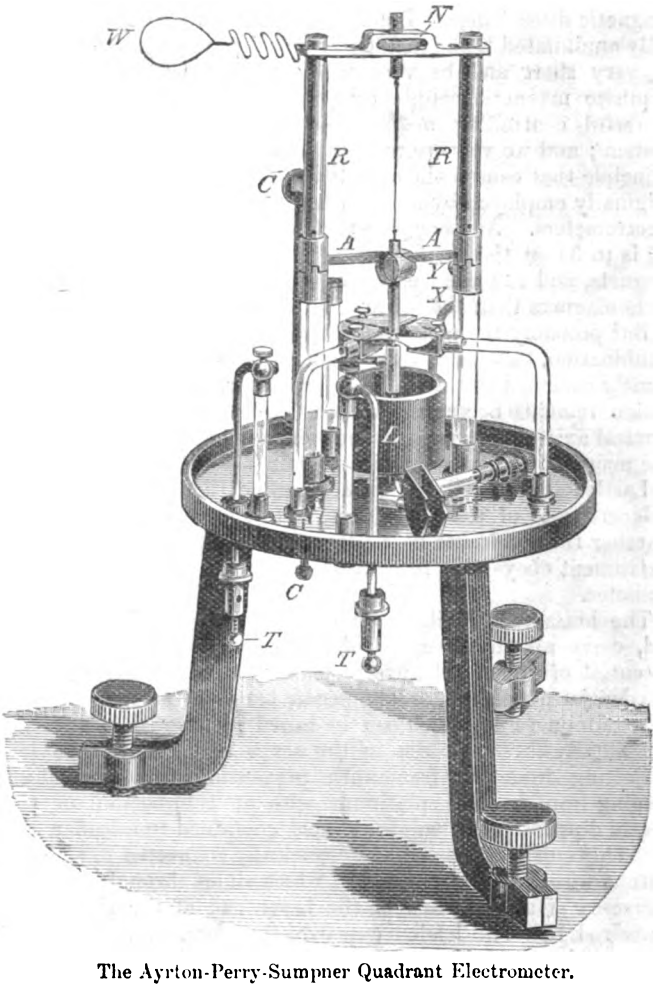
IMPROVED QUADRANT ELECTROMETER.*

The first condition to be fulfilled in designing an electrometer, indeed we venture to think in designing any electrical measuring instrument, consists in supporting all the working parts from the base, so that on removing the cover, all the parts can be got at and adjusted in position. We therefore commenced by turning Sir William Thomson's electrometer upside down, so to say, supporting the quadrants, needle, charging rod, &c., from the base, and using the glass shade which covers up our instrument as the Leyden jar.

The engraving shows an instrument with this glass shade removed, the springy wire W being for the purpose of making connection with the interior of the Leyden jar; and it will be seen that every part of the interior can be easily got at without interfering with the adjustment and without having to first clamp the needle. Further, not merely are the insulating stems that support the needle and the quadrants protected from dust and moisture, when the cover is on, but also the insulating stems that support the brass terminals T, T, and the charging rod C C. Hence there are no exposed ebonite stems requiring daily rubbing to remove dust and moisture, an operation that not unfrequently electrifies them, resulting in a slow charging of the quadrants when they are insulated. When the instrument is not in use the holes in the base plate through which pass the terminal rods T, T are closed by means of brass plugs sliding on the terminal rods and pushed up from below.

In the White form of electrometer the charging rod can be electrically disconnected from the interior by the short ebonite tube, which holds it, being turned by the fingers. To do this, however, the ebonite tube must be tightly grasped in one's fingers, and as they are necessarily chemically dirty, there is the possibility of the Leyden jar being partially discharged in the act of disconnecting the charging rod. This objection is entirely overcome with the arrangement which we have adopted for the charging rod in the improved quadrant electrometer. At the top of a glass rod is cemented a cap, to which is attached a piece of brass, to the lower end of which is fixed a pivot, round which the charging rod C C can turn. The ball C at the upper end of this rod is made of lead, and its weight causes the rod to remain in either of two positions. When in one position the ball C is in electric contact with the needle, guard-tube, and the interior of the Leyden jar, the area of contact being increased by the bending of the little piece of flat spring fastened to the ball. The Leyden jar can now be charged, and at the moment that the right amount of charge has been given, the charging rod C C is tilted over into the other position. This tilting over is easily done by pushing the lower end of the rod with the electrophorus, if an electrophorus be used to charge with, or by means of a glass rod, or by slightly pulling the wire attached to the binding screw at the lower end of C C, if such a wire be used to charge through.

When this electrometer is employed for alternating-current work it is desirable to connect the binding screw B by means of a fine wire with a binding screw attached to the interior of the instrument, so that the electric contact between the charging rod and the interior of the instrument (which should be very good for very rapid reversals of the charge) does not depend solely on the pressure of the leaden ball at the top of C C. It is also desirable, when an electrometer is employed for measuring a rapidly alternating potential difference, that



The Ayrton-Perry-Sumpner Quadrant Electrometer.

the electric connection between the electrodes and the quadrants should be far better than can be obtained with the comparatively slight pressure that exists between the ends of the electrodes and the quadrants in the White form of instrument; hence in the improved quadrant electrometer the connection with the quadrants is made by means of screwed contacts. Further, for alternate-current work it is not only important to have as good contacts as possible, but also as little capacity as possible in the electrometer. This result we attain by removing the springy wire W, and electrically connecting the interior metallic coating of the glass shade with the exterior.

The next point to consider in designing this instrument was the size to give to the needle and quadrants. Theoretical reasoning, confirmed by some roughly made experiments, showed that the sensibility of the quadrant electrometer could be much increased if the needle and the quadrants were made smaller than in that instrument. We therefore made the

* Abstract of a Paper by Profs. W. E. Ayrton, J. Perry, and Dr. W. E. Sumpner, read before the Royal Society, June 4, 1891.

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diameter of the quadrants, their vertical depth, and the length of the needle about six-tenths of the size adopted in the White pattern. Feeling, however, that the needle in the White pattern was not broad enough at the widest part to prevent its edges approaching too near the intersection of the quadrants when the needle was deflected, we thought it better not to reduce the width of our needle in the same proportion as its length. Therefore, while we reduced its length to six-tenths we left its breadth eight-tenths of the sizes adopted in the White electrometer.

Then as regards the controlling force. In our laboratories are electrometers with a bifilar suspension control, a torsional control, and a magnetic control respectively, and of these three forms we have found that the magnetic control is the best to be used in an electrometer, whose sensibility we require to be able to easily vary. The bifilar suspension control is unnecessarily troublesome, arising partly from the frequent necessity for adjusting for equal tension in the two fibres.

The magnetic control has no doubt the defect that the position of the needle is liable to be affected by outside magnetic disturbance. But this source of error can be practically annihilated if the magnet attached to the suspension wire be very short and be very weakly magnetised, and if the requisite magnetic couple be produced by the use of a very powerful controlling magnet placed near to the suspended system; and we venture to think that it was a neglect of this principle that caused the abandonment of the magnetic control originally employed by Sir William Thomson in his quadrant electrometers. Another plan that we have found very successful is to fix on the suspension wire an astatic combination of magnets, and to place the controlling magnet nearer one of the little magnets than the other.

But probably the most perfect plan is to use, as the astatic combination, two little vertical magnets, which may be conveniently attached to the back of the mirror, since such a combination remains necessarily astatic as far as rotation round a vertical axis is concerned, no matter how much one or both of the magnets may weaken with time.

Lastly, we supported the lower part of the guard-tube quite independently of the upper part, and hence the result is that, whether the quadrants be pushed far in, or pulled far out, this instrument obeys the recognised formula for a quadrant electrometer.

The brass rods R, R, which are each supported on a glass rod, carry all that portion of the apparatus that is at the potential of the needle, except, of course, the interior of the Leyden jar glass shade. The needle hangs by means of a silk fibre from a screw which can be raised or lowered by turning the nut N, a vertical slot in the screw and a horizontal pin projecting from the framework preventing the screw itself turning round. The platinum wire at the bottom of the needle dips into some sulphuric acid contained in a leaden cup L. This cup is supported and electrically connected to R, R by a stout wire X, the upper end of which slides through a clamping screw Y at the back of the lower end of the right-hand brass rod R. The leaden cup can, therefore, be easily raised or lowered and also centred. Similarly the lower portion of the guard tube is carried by a stout wire passing through a clamping screw at the back of the lower end of the left-hand brass rod R. After being put into position the tube is closed round the platinum wire, which projects down from the needle, but so as not, of course, to touch this wire.

The upper portion of the guard-tube is made in two halves, which are carried by the arms A, A attached to collars sliding with a bayonet-joint motion on the rods R, R. By raising up these collars and turning them round the two halves of the upper portion of the guard-tube can be opened, and the mirror and the wire attached to it got at. In fact, by opening and turning aside both the lower and the upper portions of the guard-tube, the mirror, needle and its attached wire can be left hanging freely from the silk fibre suspension, and it can be seen whether they are hanging properly or whether they require adjustment.

We have to thank Mr. Mather for taking a leading part in designing and constructing this improved quadrant electrometer.

HIGH-PRESSURE EXPERIMENTS.

The 130,000-volt 50 H.P. transformer, exhibited by Messrs. Swinburne and Co., at the Crystal Palace, was used on the 13th inst. at the first demonstration of a series of experiments which will add another attraction to the Exhibition. A considerable number of electrical engineers and representatives of the Press had been invited to a private view of this interesting "side-show." The transformer had been wound for 100 volts on the primary, with the intention of using it on an ordinary lighting circuit. As no suitable supply was provided by the management of the Exhibition, the Brush Electrical Engineering Corporation placed their large Mordey alternator at the service of Messrs. Swinburne and Co. for the purpose of these experiments. The voltage of the alternator being 2,000, step-down transformers of the ordinary Hedgehog type were used, giving 150 volts. A multiple-point resistance switch and a resistance composed of a pair of iron wires in an alkaline solution were used in the intermediate circuit. The transformer was enclosed in a large earthenware case, and within this, surrounded by oil, another case contained the transformer itself.

Some preliminary experiments were made with high frequency currents, by means of a condenser and an air blast. Vacuum tubes were suspended from a horizontal wire, and a few square inches of tinfoil hung below each tube served to increase the capacity. Although, as in Mr. Tesla's experiments, no return connection was made, the vacuum tubes glowed. The rest of the experiments were conducted solely by the current derived from the transformer, without any condensers or air blasts. Mr. Fox Bourne was in charge of the apparatus, and explained the effects. A sparking distance of 6in. between two pieces of fine wire was bridged by the high-pressure discharge, and it was possible, by allowing the engine to attain full speed, to start a discharge across even a greater interval. With polished copper hemispheres about 4in. in diameter, the sparking distance with the same voltage was reduced to less than 2in. When the discharge passed, the arc rose to the upper part of the hemispheres, which were placed at the same level, thus lengthening itself and rising up in an arched form, this being due probably to the mutual repulsion of the different parts and to the slight draught owing to the heating of the air. When two wires were brought within a few inches of each other, the arc in a similar manner tended to increase its length, running away from the place where it was started, and terminating at some angular projection of the wire. The heat at this point was sufficient to melt the wire in a few seconds, the extremity dropping off. As the wire burnt away the arc lengthened out into a long wriggling flame, which finally attained a length of between two and three feet. The flame appeared to have a thickness of about one inch, but was not brilliantly luminous. It is probable, however, that the apparent thickness was partly due to irradiation. This long ribbon-like flame assumed an arched form up till the last moment, when it could no longer span the continually widening gap between the burning wires.

A discharge was made to pass under some thick resin oil, and a little difficulty was experienced in preventing the formation of an arc across the wires above the surface, since the points beneath the oil had to be placed very close together compared with the distance between the leading-in wires. As soon as the discharge passed beneath the oil a loud spluttering gurgling noise was heard, and a small volcanic eruption with a yellow flame 2in. or 3in. high rose above the oil. This was repeated several times, and it was evident that when a considerable amount of power is used, amounting in this case to perhaps some 8 or 10 H.P., the oil has no self-healing properties. This absence of a property, which is well marked and extremely useful in cases of intermittent contact at low pressures, is no doubt due to the fact that with the rapid and continuously repeated discharges of an alternating-current dynamo, the viscous oil has no time to flow back upon itself, and the current is so large that a very material quantity of carbon is formed, which, together with the vapour of the oil, forms a good path for the current.

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Several of the other experiments were similar to those which have already been described in our account of the recent meeting of the Old Students' Association (see *The Electrician*, March 18th, page 512). A piece of roofing slate permitted the passage of a continuous discharge from one corner to the other, the slate itself becoming hot, showing that an actual current had passed through its substance. A piece of dry pine, 2ft. long by about 2in. wide, and ¼in. thick, was subjected to 130,000 volts for some minutes, and sparks began to crawl out, partly on the surface and partly beneath it, from the copper wires bound round the ends. The path of the sparks was very irregular, and presented a branched appearance; the creeping discharges finally met, and the piece of wood burst into flame. An arc was formed, and at once rose, writhing and roaring in an arch over the flames. The brilliant effect produced by placing a sheet of glass between the terminals of a high-pressure alternating circuit was shown on a very large and beautiful scale, the glass being finally pierced. It was difficult, in these experiments, to utilise the whole of the 50 H.P., since all insulating substances broke down. At 130,000 volts it is possible to pass a small current through a man, and to transform it down and run a 2-H.P. motor. This experiment, however, was not performed. With a pressure of 130,000 volts this transformer could work a 50-H.P. motor placed in America through a wire a tenth of an inch diameter with a loss of only 2 H.P. on the way. The maximum current during these experiments was probably about one-half an ampere. The slate-pencil arc and the curious depression in the surface of the oil, and various other experiments, which have been already described in our columns, were very much appreciated by the large audience which had been invited to witness them.

A BURIED MICROPHONE.

BY ALEX. J. S. ADAMS.

A microphone was recently buried in the earth, in connection with the study of cosmical variations; and whilst the general result is for use in connection with that subject, the details of the experiment may warrant being separately told. It may be premised that the idea was to test whether a tidal movement of the earth's crust could be rendered manifest by the use of a microphone.

A shaft 4ft. square was driven to a depth of 16ft., through strata of subsoil, sandy clay, and sandy gravel. At the bottom of the shaft a hole was bored laterally for the packing away of the apparatus. The apparatus consisted of a single pencil of fine carbon, resting in cavities of fine carbon blocks. The wire connections were made by twisting tinned copper wire round the blocks, and clamping the whole together between two stout pieces of mahogany—this was fixed within a large glass jar. The gutta-percha connecting wires were passed through the cork stopper; the jar was heated to reduce and dry its atmosphere, and the cork then fixed in the neck with hot Chatterton's compound. The gutta-percha leading wires were served with warm tarred tape. The jar was dipped in warm tar, and all were then sanded. Within the jar was also placed a phial containing a record of the date and particulars. The jar was tightly packed into the lateral hole, a little over 16ft. below the surface; the leaders were brought up at one corner, and thence to the top of a high pole, from which they were extended through the window casing into the study. The gravel and soil were replaced and carefully punned, and it seemed that under the circumstances some sort of answer should be forthcoming from the arrangement. By means of a switch, the buried microphone was connected to a sensitive telephone, and one Leclanché cell.

During the quiet of many nights sound was intently listened for, and occasionally a faint grating was heard; but from the facts that it was chiefly after heavy rain, which caused a subsidence of the newly replaced earth, and that since the cessation of appreciable subsidence the sound has not been heard, it is believed the grating noise was due to settlement of the gravel. Beyond this, attentive listening never fails to discover a faint *breathing* in the circuit, as if fine sand particles—or, rather, dust particles—were constantly impinging upon the buried carbon: a sound without any variation, and which experiment amply proved to exist at the buried microphone.

The phenomenon suggested many things in explanation; but it was only by accident that the sound became understood. It happened that upon the accidental loosening of the spring contact of a switch, which was being used in an endeavour to reproduce the *breathing* in another microphone, that the sound became apparent, and, further, that by tightening or loosening the contact it could be produced at pleasure. It was evident that the bad switch-contact became virtually a microphone, and induced a self-effect. As a result this breathing can now be produced at will in either of the microphones in my possession.

The point seems of some importance, because whilst I am not aware that this microphonic self-effect has been previously noticed, the effect itself is a guarantee that the buried apparatus is sensitive, and that though the instrument remains undisturbed to the end of time, its breathing will be the evidence of its condition.

It is thus seen that the effects obtained are clearly explainable; and even if the apparatus be considered inadequate to the purposes of the test aimed at, the experiment *per se* is nevertheless of interest.

THE WORK OF JOSEPH HENRY.*

And now let us go over the ocean to Faraday, and see how he asks the great question. Bence Jones tells us that as far back as 1824 Faraday began the study of the subject. "He believed"—as did Henry—"with all his energy, that as voltaic electricity powerfully affects a magnet, so the magnet ought to exert a reaction upon the electric current;" and he makes an experiment which nearly makes the discovery. He again makes experiments in November, 1825, December, 1825, and April, 1828, but without result. "*The momentary existence of the phenomena escaped him.*" In the beginning of the year 1831 comes over the sea Henry's Paper in *Silliman's Journal*. It describes the magnets that have sprung up under Henry's hands and the rules of their construction. Faraday, with quick philosophic instinct, sees in these powerful instruments for producing magnetism means for a new trial of the old experiments, and again he goes to work. "He began his experiments on August 29, 1831." The essential apparatus, the means of the discovery used by the two men, like the discovery itself, is identical. Faraday saw his needle "oscillate," as Henry saw his "swerve," at the making and the breaking of the galvanic current. There is, however, a marked difference in the immediate mental attitude of the two men in regard to the observed phenomenon. Henry sees instantly that the question is answered. Faraday, on the other hand, does not seem to have understood the reply of Nature, or at least he seems far from confident of it. He writes to a friend the 23rd of September, "*I think that I have hold of a good thing; I cannot say. It may be a weed instead of a fish that after all my labour I may pull up.*" On the next day, September 24th, the third day of his experiments, he is again trying the effect of a helix of wire conveying the voltaic current of 10 pairs of plates upon another wire connected with a galvanometer, and other like experiments, but "*no induction sensible.*" Had Faraday at this time discovered the essential nature of the phenomenon, experiments like these could not have failed, in his hands, to give conclusive results. "He gave up experiments for that day with the electro-magnet and tried instead the effect of bar (permanent) magnets." An iron cylinder had a helix wound around it. The ends of the helix were placed between the poles of the magnet. Every time the magnetic contact was made or broken there was motion in the galvanometer. Now, but not until now, he reaches a positive

* Abstract of Articles IV. and V. of a series by Miss Mary A. Henry, appearing in the *Electrical Engineer* of New York. For abstracts of previous articles see *The Electrician*, January 29th, February 5th and 19th.

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conclusion: "Hence here distinct *conversion of magnetism into electricity.*"

This constitutes his first distinct announciation of the phenomenon, so that his discovery can scarcely, in justice, be said to have been made until this day, September 24, 1831.

Not until the ninth day of experiment, October 17th, does he produce the deflection of the needle by thrusting a bar magnet into a helix of wire; the experiment which came over to Henry in that brief paragraph of April, 1832, and which incited him to repeat his own experiments in the last two weeks of June of the same year. With no other knowledge of Faraday's work than this particular mode of producing the effect, it is curious to see Henry in these June days bending the armature of his magnet into a ring; while, on the other hand, Faraday, equally unconscious of Henry's efforts, in his Paper of November, 1831, makes the important observation that "a soft iron bar, in the form of a lifter to a horseshoe magnet, when supplied with a coil of this wire, becomes, by juxtaposition with a magnet, a ready source of a brief but determinate current of electricity," thus adopting the precise method which had been employed by Henry.

Miss Henry then gives in full Bence Jones's account of Faraday's work up to September 24th, so that the reader may be enabled to judge for himself whether she has interpreted it correctly.

Then follows the experiment usually given in the text-books, as the one by which Faraday made the discovery:—

"'The fifth day of experiment was October 17th. Paragraph 57 describes the discovery of the production of electricity by the approximation of a magnet to a wire.

"'A cylindrical bar magnet, ⅞in. in diameter and 8½in. in length, had one end just inserted into the end of the helix cylinder (220ft. long); then it was quickly thrust in the whole length, and the *galvanometer* needle moved; then pulled out, and again the *needle moved*, but in the opposite direction. This effect was repeated every time the magnet was put in and out, and therefore a wave of electricity was so produced from *mere approximation of a magnet*; and not from its formation *in situ*.'

"The ninth day of his experiments was October 28th, and this time he made a copper disc turn around between the poles of the great horseshoe magnet of the Royal Society. The axis and the edge of the disc were connected with a galvanometer. The needle moved as the disc turned.' The next day, November 4th, he found 'that a copper wire, ⅞in., drawn between the poles and the conductors produced the effect.' . . .

"In ten days of experiment these splendid results were obtained. He collected the facts into the first series of *Experimental Researches in Electricity.* It was read November 24th at the Royal Society. Then he went to Brighton."

The great discovery of magneto-electricity is made. They were not conscious rivals, these two great men. Widely separated, each was simply intent upon finding out what nature had to teach. If one had failed to make this gift to the world the other would have done so. We desire to make no ungracious comparison between them, yet it is but just to consider the position which each held in reference to the discovery.

1. As to advantage of circumstance. Faraday, with nine years of advantage in age, has been at work in the Royal Institution of Great Britain for eighteen years, surrounded by every facility for study; with ample time at his command, and under the instruction of one of the most eminent men of the age. Henry, in what was then a frontier town of a new country, with no other aid than his own earnest purpose, has had to snatch his days of investigation out of busy years filled with other matters; his only apparatus rude tools made by his own hands.

2. Faraday has been at work upon the subject since 1824; has tried it again and again "without result," although the phenomenon, unperceived by him, has been actually produced under his hands. Henry succeeds in his first attempt.

3. As to the means of the discovery, Henry's magnet. He had sent it over to Faraday in *Silliman's Journal.* In making it he had made the stepping stone for both: had made it easy for Nature to answer the question. We might almost say the magnet made the discovery.

4. As to priority: And now we come to the chief object of our story. It has been hitherto supposed that Faraday could claim this; but is it so? Certainly, on the score of publication. His first series of brilliant experiments was given to the world in November, 1831, while Henry's Paper did not appear until July, 1832; but the world, advancing rapidly in every way, will soon no longer ask who was the first to *publish*, but who was the first to *do*. Which of these men was the first actually to make this discovery?

Let us attend first to Henry's spoken statements. Often by the fireside in his home he told to his wife and daughters the story of this great early disappointment; the story, in fact, as we have given it. How he made the discovery of the extra current five years before Faraday. How the discovery of magneto-electricity followed in 1830. How eager he was to pursue it, and how baffled by lack of time and materials. How he wished to amplify his results before he gave them to the world, and how he had commenced his great preparations for this purpose; and then, one day, in the library of the academy, seizing eagerly upon a newly-arrived periodical, how he suddenly came upon the notice which told him that although he had made the discovery so long before anyone else, Faraday must claim it. He might hurry his results into print, but Faraday was there before him. "He who publishes first claims the discovery" was a code strictly held by Henry; and so he laid down all claim to the discovery, and in the years which followed in Princeton always attributed it in his lectures to Faraday. An old friend (Rev. Theodore L. Cuyler, D.D.) one of Henry's earliest pupils in Princeton, said recently to one of his daughters, "Your father often spoke to me of his disappointment about that discovery. 'I ought to have published earlier,' he used to say. 'I ought to have published, but I had so little time. It was so hard to get things done. I desired to get out my results in good form, and how could I know that another on the other side of the Atlantic was busy with the same thing?'"

Let us now study the evidence which lies under our eyes, in the published statements, and the one or two letters we have collected in this article, and see whether they corroborate our story. Bence Jones says that Faraday commenced experimenting the 29th August, 1831, and that "the first experiment detailed in his note-book records the discovery." The experiment with the ring was made that day or the next; but the discovery, as we have shown, was not really made until the 24th of September, when he first recognised positively the distinct conversion of magnetism into electricity. However this may be, *the 29th of August is the utmost limit for earliness to be claimed for Faraday.*

And now let us look at Henry's Paper. We have given it entire, so that the reader may judge what it seems to say. It is published in July, 1832, but in its beginning it refers to last August, *that is August*, 1831, *the very August when Faraday is making his ring.* Henry says experiments were interrupted then, not to be resumed until "*the last few weeks*," which we find from the latter part of the Paper means "*the last two weeks* in June" (that is of 1832). A letter to Prof. Silliman gives us the cause of this interruption, namely, that the room used by Henry was required for the opening of the academy, and from another source we learn that the academy opened the 1st of September. So this is the first thing we learn, that Henry is busy with the subject at the same time that Faraday is, in August, 1831, and that between that time and the last two weeks in June there is an interval in which there are no experiments.

The second thing we learn from the Paper is that in this interval, "in the meantime," Henry says, comes a brief notice of Faraday's results dated April, 1832, and which Henry gives in the Paper.

Now look again into the Paper. It consists of a description of two series of experiments, *the one made before, the other after, seeing the notice of Faraday's result, dated April*, 1832. In the first series we find the great experiment. *If made before April*, 1832, *then before the close of August*, 1831, *the time when experiments stopped;* and into the very last of those August days must we bring the experiment in order to give Faraday priority, the utmost limit of earliness for Faraday being August 29th.

It is not likely that Henry was at work on the last day of August; he had to give up his room to be cleaned, to remove his apparatus. But if at work, what is he doing? Not making

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this discovery—it has been already made. We are not left to conjecture; he tells us in his Paper with what he is busy in those August days, "*making a great magnet and other preparations for a series of experiments with it on a large scale, in reference to the production of electricity by magnetism.*" Henry does not say in his Paper when in August the magnet was commenced, but considerable time must have been consumed in its construction before the 29th came. He had to stand over the workmen while they forged that bar weighing 101lb. The insulating and winding of that reel of wire, a mile in length, alone represents an enormous amount of time, to say nothing of the winding of the magnet. Henry must have been at work from early in the month, on these preparations for his extensive series of experiments when that memorable August 29th came, and so we drive back the initial experiment *made before these preparations were begun*, to pursue the subject on a large scale. But it matters not for our present purpose whether this experiment was made days, weeks, or months before that August 29th, since it was before, to give Henry priority.

And so again is our point proved, since on the only day into which we must force Henry's experiment in order to give Faraday priority, Henry is distinctly busy *about something else.*

Does the Paper tell us anything else to throw light upon the date of the discovery? The magnet upon which it was made tells us something. Henry tells us in his Paper that the galvanic magnet used was the one described in *Silliman's Journal*, Vol. XIX.; the one he had made to sustain seven hundred pounds. The date of the Paper in which it is described is January 1, 1831, and the magnet was made in 1830. Thus is fixed for us the limit of earliness for Henry, that is, 1830. But there is something more in the use of this magnet. It suggests the probability that in this year 1830 the experiment we are in search of was made, because in January, 1831, was constructed the great magnet for New Haven, which remained in Henry's laboratory until spring came to break up the ice in the Hudson and allow it to be taken to its destination. With this more powerful, more complete magnet, in his possession, it is natural to suppose Henry would use this to ask the important question, rather than the earlier and inferior one, unless the experiment had been made before the construction of the larger one.

ELECTRIC LIGHTING OF BUOYS IN NEW YORK HARBOUR.*

Comparatively few people, other than those directly interested in the subject, have any idea of the difficulties experienced by vessels desirous of entering the harbour of New York, or of the magnitude of the works established and maintained by the Government for the safe guidance and protection of shipping interests in this, America's greatest port of entry. There are only two narrow channels through which vessels of average draught can pass, and only one which can be used by the larger ships, such as the transatlantic steamers. The entire bottom is covered by treacherous shoals and sandbars, and necessitating the use of no less than 80 buoys, 13 lighthouses, and two lightships to mark the dangerous localities and proper channels to be followed. The deep draught vessels are obliged to take the long and less direct route through Gedney's Channels, and it is here that a vast amount of time and money has been expended. Up to the fall of 1888, the entrance to Gedney's Channel was practically closed at night, having no distinguishing marks, except unlighted buoys. In 1888, however, in view of the great increase during recent years in the number, draught and speed of ocean steamers entering this port, together with the demands of commerce, the Government went into the matter very thoroughly, and a system of improvements was started which to-day, after an expenditure of over $2,000,000, has resulted in opening up a highway to the city 1,000ft. wide, with a depth of 30ft. at mean low water, through which vessels of the deepest draught can safely enter the harbour and proceed at once to their docks, at any hour of the day or night.

Owing to the constant changes in the course of the channel, from the action of the tides, it became a somewhat difficult problem to decide as to what was the best method of clearly defining its limits.

After much careful investigation and taking into consideration the peculiar requirements of the case, it was finally decided that a buoy in the form of a long spar, having its lower end securely shackled to an anchor or heavy sinker resting on the bottom, would be best adapted to withstand the effects of heavy seas and floating ice, and least liable to be displaced or broken by collisions with passing vessels. This being determined, the next important question was the manner in which the buoys were to be lighted, and here electricity came promptly to the front. It being clearly demonstrated that electric lights on the buoys would prove entirely satisfactory, so far as the brilliancy of the light itself was concerned, experiments were immediately instituted to give the best means of conveying the current from the shore to the buoys a practical test. The Bishop Gutta Percha Company, of New York, were consulted, an armoured cable was manufactured, and an experimental line was laid to a spar buoy near the Robbins Reef lighthouse, a distance of about 6,000ft. The buoy was fitted with an iron cage at the top, enclosing a heavy glass jar containing the lamp, and, after a variety of tests at different seasons and at varying states of the weather, a system was finally adopted suitable to the conditions prevailing in Gedney's Channel; and upon the approval of the Lighthouse Board, the necessary preparations for the erection of a permanent plant were promptly begun, and in November, 1888, the entire system was in operation. In consideration of the fact that the buoys in Gedney's Channel are, at the present time, the only ones in the world lighted by electricity, a few words in relation to the means adopted to accomplish this result may prove of interest. The channel marked by these buoys is 1,000ft. wide and about 6,000ft. long.

Two lines of heavy armoured three conductor cables, manufactured by the Bishop Company, are run to junction boxes, one on either side of the channel. Spliced to these main cables, inside the junction boxes, are three separate single conductor cables of lighter make, connecting the three buoys on either side of the channel, which are located about 2,000ft. apart, with the main line. One of these single conductor cables is spliced at the lower end of each buoy with the cable running up to the lamp, this wire being laid in a deep slot in the side of the buoy, and covered and protected by a strip of wood fitting closely over it and let in flush with the outer surface.

The buoys themselves are about 50ft. long, and are made of a species of juniper wood found in the dismal swamp of Virginia, this timber being selected on account of its buoyancy and straightness of growth. They average from 10in. to 12in. in diameter at the top and bottom, and 15½in. at the largest section, and are shackled at the bottom to a cast-iron sinker, weighing 4,500lb.

The protecting cage, in which the incandescent lamp is set, is composed of flat iron ribs, riveted to two iron bands encircling the spar, with a third ring at the top of the cage which serves as a handle (see Fig. 1). The upper part of the ribs and the top ring are turned so as to present the edge to the lamp, thus securing greater strength and obscuring the light as little as possible.

The lantern itself, which fits securely inside this cage, consists of a circular base and stout framework of brass, having curved panes of thick glass in the sides, and segmented panes at the top. It is so constructed that it can be lifted bodily out of the cage, thereby bringing away everything liable to need repair or other attention. Three short legs attached to the bottom ring fit into holes in brass ears riveted to the ribs, and the lantern is secured in place by two hinged screw clamps, which are also secured to the ribs.

The lamp is rated at 100 c.p., and the carbon is extra heavy and has three loops in the centre, designed to give a distribution of the light as uniform as possible. One terminal wire of the lamp is connected to the bars of the lantern, and the other is carried through an opening having an insulated bushing and connected with the core of the cable. One of the armour wires of the cable is soldered to a rib of the cage to insure a complete circuit through the core of the cable, the lamp and the lantern and frame to the cable armour.

The cables, originally laid, have given excellent service, and, considering the very hard usage to which they have been subjected, are still in first-class condition. The main difficulty that has been experienced is from mechanical, and, in many instances, malicious injury done to the cables, principally from vessels anchoring in or near the channel and getting the cables entangled in their anchors. In these cases the cable has been lifted from the bottom, and instead of being freed and allowed to drop back into position, has been deliberately chopped through and left for the lighthouse tender to pick up and splice together. There is no redress to be had for this kind of work, even if the guilty parties are known, as the Courts have decided against the cables and in favour of the vessels anchoring, which they continue to do, although warned against it by a large sign on Sandy Hook, which can be seen in the daytime and by a red segment set in the Hook beacon which covers the cable territory at night.

Since the service has been inaugurated the original heavy lantern has been changed for a lighter one, and straight glass has been substituted for the curved panes first used, so that they can be more readily replaced if broken. The lamp is also so adjusted as to

* From the *Electrical Review* of New York (Abstract).

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enable it to be taken out without removing the entire frame, if necessary, although the lantern can still be lifted out as formerly, if desired. The colour of the lights has also been changed, or rather they have been differently located, those on the starboard side of the incoming vessels being now all red and those on the port side all white, instead of alternating, as they were originally.

As an instance of the hard usage to which the buoys and lamps are sometimes subjected, and the excellence of the service rendered under those conditions, it is only necessary to mention that during the severe storm of January last the ice surrounding the lamps was as thick as a good sized barrel, and the weight of this ice, combined with the heavy sea, was sufficient to keep the buoys for the greater part of the time completely under water, In spite of this, and regardless of the mass of ice surrounding them, the lamps continued to burn brightly and without injury, and, as often as they could manage to get their heads above water, were plainly visible from the shore of Sandy Hook, a distance of nearly three miles.

The three years' practical demonstration of the feasibility of this system of lighting, and in view of the excellent results attained therefrom, the only drawback being, as before stated, from mechanical injury to the cable itself, it was decided, a short time ago, that in order to insure the best results in the future it would be advisable to substitute a still heavier armoured cable than the one now in operation, at least at the channel end of the line, where it was most liable to injury. Accordingly, the Bishop Company received an order for about 18,000 feet of new cable which would fill these requirements, and have turned out an article which, it is hoped, will prove durable enough to warrant its adoption throughout the entire system of coast lighting.

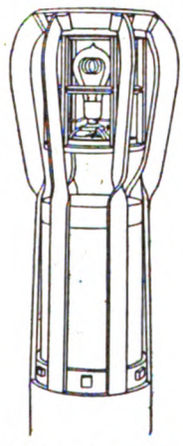

FIG. 1.—Protecting Cage for Incandescent Lamp at head of Spar Buoy.

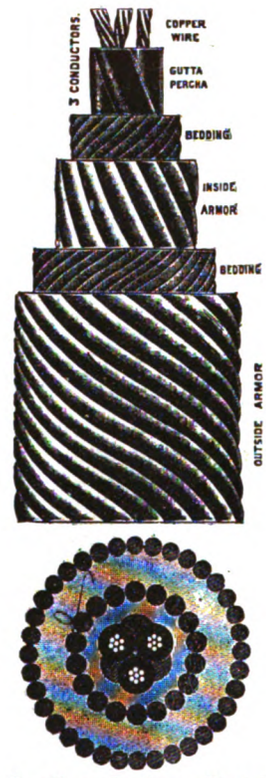

FIG. 2.—Three-Conductor Electric Light Cable, used in connection with the Buoys in Gedney's Channel, New York Harbour

The new cable (Fig. 2) a longitudinal and cross section of which is here shown, is similar to the first one, in so far as the conductor wires and insulation is concerned, this part having proved entirely satisfactory. Over the first or inner armour is a bedding of strong tarred hemp saturated with a bituminous compound, designed to keep the zinc of the galvanised wire intact, and so prevent rusting. This again is covered by a second iron armour, which is wound on with a "short lay," in order to reduce as far as possible its tendency to kink when dragged from position by the tide, anchors or other causes. When finished the whole cable is treated to a bath of hot bitumen, and is then ready for laying.

The tide eddies, combined with the heavy swell prevailing off Sandy Hook, furnish a large element of difficulty to be overcome in making repairs to the cables when necessary. This work is generally done from one of the lighthouse tenders, except in heavy weather, when it is customary to use a large cargo boat, as it can be handled more readily and with less danger of breaking the cables. When first laid, and for some time thereafter, the splices were made by the *employés* of the Bishop Company; but latterly the men at the station, who from the first have shown great interest in the work, have become so proficient that they are able to handle all the necessary repairs themselves; and this has proved a great advantage, not only in the matter of time and expense, but also from the fact that oftentimes they have been called upon to repair a break in bad weather, and have been able to do the work while tossing on a sea that would compel the average landsman to "give it up," together with whatever else he had with him. The matter of raising a cable successfully in order to make a splice is by no means an easy matter, as they are frequently found to be covered with from 6ft. to 8ft. of sand, causing a very severe strain in raising, and requiring great care to avoid breaking. It generally takes about three hours to splice one of the single conductor and four hours for one of the triple conductor cables.

The power station on Sandy Hook, from which the current is supplied for the buoys, is a model of efficiency, and no trouble of any kind has been experienced here since the plant has been in operation. Every part of its equipment is of the best, and no effort has been spared to insure the best results. All the working parts are in duplicate, and the failure of the lights through any accident to the steam or electric plant is simply out of the question. The station itself is a compact and substantial brick building, two stories in height, with a one-story brick extension containing the boilers. These, of which there are two, are of the upright tubular type. The average pressure of steam carried is 84lb. with a daily consumption of 680lb. of coal. The engines are of the Armington and Sims horizontal automatic type. They are of about 7 H.P., the cylinders are 6in. in diameter with a 7in. stroke, and are run at 380 revolutions per minute. The entire electrical outfit was furnished by the Edison Manufacturing Company, of New York. The dynamos are continuous current compound wound machines making 1,720 revolutions per minute, and generating a current of 25·5 amperes, with an E.M.F. at terminals of 160 volts. The wires are supported on a line of substantial poles to the beach, a distance of about 1,500ft., where they are connected to the cables. The cost of the entire plant, including a naphtha steam launch built purposely for attending the buoys, was $19,530, and the average operating expenses per month are about $400.

The average efficiency of the entire system, taking the total number of lights for every night of their first two years of service, and deducting therefrom the time any of them were out of order, from whatever cause, leaves the percentage of perfect service rendered 93·61, which, on the whole, is a most excellent record. Now that the officers and men at the station have acquired their experience in working the cables and buoys, and the fact that a heavier cable has been laid, which will be less liable to damage, the record for the next two years should be even better than that already shown, and it seems reasonable to infer that the excellent results already obtained will eventually lead to the general adoption of this system of lighting throughout the service.

THE DANGERS OF BARE COPPER UNDERGROUND MAINS.*

BY J. A. MONTPELLIER.

The employment of bare copper conductors laid in underground troughs may under certain conditions give rise to accidents, which it is worth while to point out. This system, as is generally known, has been used in Paris in the districts allotted to the Compagnie Continentale Edison, the Compagnie Parisienne d'Air Comprimé et d'Électricité, and the Société d'Éclairage et de Force par l'Electricité.

With perfectly watertight concrete troughs, fairly good results have been obtained, in spite of the inevitable current leakage. The conductors, however, are soon covered with a layer of carbonate of copper, which in some cases becomes thick enough to appreciably diminish the cross-sectional area of the conductor, and render it consequently of far higher resistance. Owing to this fact the conductors become more heated by the current; and the rise of temperature, added to the damp which prevails in the troughs, stimulates the production of carbonate of copper. A time must, therefore, sooner or later arrive when the conductors will be so corroded as to be no longer utilisable. We can, it is true, in a certain measure, impede the production of carbonate of copper by covering the conductors with a bituminous compound analogous to that used to protect the iron sheathing of submarine cables; but we should then be using a kind of insulated conductor, and consequently abandoning the system of bare conductors. Without making a definite pronouncement as to the

* From *L'Electricien.*

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efficacy of this process, it is almost certain that the use of this bituminous composition would remedy most of the defects pointed out—that is to say, it would reduce the current leakage to more reasonable proportions, and it would prevent the destruction of the copper.

When the conduits are not perfectly watertight far more serious accidents than those alluded to may occur, a striking proof of which was the explosion which recently took place in a manhole in the Rue Taitbout, belonging to the Edison Company. In certain narrow streets the Edison Company, seeing the impossibility of running the concrete conduits usually employed, adopted rectangular stoneware troughs. It was this type of conduit which was laid down in the Rue Taitbout, where the accident took place. The result of this explosion was to project a cast-iron manhole lid to the height of a first story, fortunately without any other consequence than injury to material. The cause of the explosion can evidently only be attributed to the firing of explosive gaseous mixtures. What are these gases, and under what conditions are they formed? In the case under consideration, illuminating gas being deemed out of the question, since no gas escape was detected in the vicinity of the electric mains, the explosive mixture must have been composed either of oxygen and hydrogen (due to the electrolysis of water) or of hydrogen and chlorine (the elements of hydrochloric acid), or perhaps of these two mixtures produced simultaneously.

The production of oxygen and hydrogen is explained quite naturally by the electrolysis of the water which percolated into the conduit. But if this reaction was a cause of the explosion, it was not the only one, since the production of the hydrogen-chlorine compound was, as we shall see, the principal cause. In fact, appreciable quantities of carbonate of soda, mixed with carbonate of potash and caustic soda, were found in the conduit. The copper conductors were much eaten away, and the layers of copper salts which surrounded the conductors were formed, not only of verdigris, but chiefly of chloride of copper. The presence of these perfectly definite saline bodies within the conduit showed that we had to do with complex electrolytic phenomena. How are the relatively large quantities of carbonate of soda and caustic soda to be explained? The only plausible explanation seems to be the following. When snow falls in Paris, a large quantity of impure chloride of sodium is thrown on the roads. The water which runs into the gutters consequently contains appreciable quantities of this salt; and it is not astonishing, therefore, that the water percolating into the conduits should be the prime cause of the phenomena observed. Under the action of the current, the chloride of sodium in solution is split up into its elements, the chlorine going to the positive and the sodium to the negative pole. The sodium immediately decomposes the water, taking up oxygen and forming soda, hydrogen being evolved. Hence, by electrolytic action, chlorine is evolved at the positive pole, and hydrogen at the negative (with formation of soda). Now, as is well known, a mixture of hydrogen and chlorine forms an explosive compound, an explosive combination of the two gases being instantly produced by an electric spark or by contact with a flame. In the present case the combination of the sodium with the oxygen of the water may well have caused so great a rise of temperature that, under certain conditions, the freed hydrogen may have been set on fire and have fired the explosive mixture.

In this way not only may be explained the explosion itself, but also the presence of carbonate of soda. In fact, the caustic soda combines very rapidly with the carbonic acid of the air, and the superficial layers thus transformed into carbonate surround the caustic soda, which, being thus protected against the air, carbonates more slowly. As to the presence of carbonate of potash, that is due to the transformation of the potassium chloride, which is always to be found in the impure chloride of sodium used to melt snow.

We therefore see that bare copper systems of underground mains may give rise to accidents; and daily experience shows that it is necessary to employ conductors which if not completely insulated are at any rate protected by an insulating varnish. The Edison Company has indeed grasped this fact, and is now carrying out the complete reconstruction of those parts of its network where stoneware conduits were originally laid down; it also proposes to cover the conductors with a protective varnish.

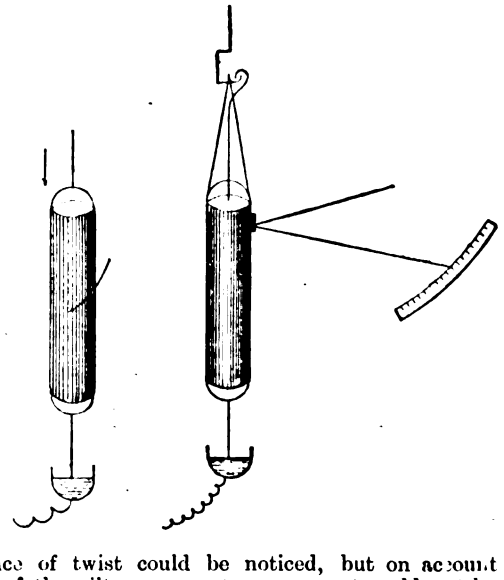
Electric Launches.—The electric launch constructed by Messrs. Woodhouse and Rawson United at their Chiswick Works to the order of the Southport Corporation, for use on their artificial lake was running during the Easter holidays with remarkable success. This boat, which will seat 40 persons, is 38ft. 5in. long, has 7ft. 6in. beam, and draws about 2ft. 3in. of water. She is propelled by a 5 H.P. "W. and R." motor.

NOTE ON THE MOLECULAR MOVEMENT IN A CONDUCTOR.*

BY PROF. A. E. DOLBEAR.

Maxwell and others have made experiments to discover whether there was any evidence of momentum in a conductor carrying an electric current. So far as I know, all the experimenters looked for a *longitudinal* momentum, that is, one in the direction of the current in the conductor, but no evidence appears to have been discovered that the molecules are thus moved. Still it is as nearly certain as anything can be and not be demonstrated, that the molecules in a conductor are moved in some way by an electric current. If they be thus moved then there must be momentum in some direction. If it be not longitudinal it may be transverse. If there should be movement in the transverse direction, what kind of experiments would be needed to show it? This is the way the question presented itself to me. When a current is sent through an *iron* wire the latter is twisted to the right or the left according to the direction of the current. This is interpreted as due to the specific magnetic quality of the conductor, for it does not occur in a copper or other conductor.

Suppose the molecules of a conductor to be *rotated*, each upon its own axis, the axis being longitudinal with the wire, what evidence of such motion would be externally exhibited by the conductor as a whole? Evidently it would be masked altogether in a common wire, for the momentum of any one molecule in one direction would be just balanced by that of the contiguous one in the opposite direction—a condition of things mechanically propagated through the diameter of the wire. In order to discover it, it would be necessary to prevent such mechanical transference of the movement, and this can be done by making the conductor a hollow cylinder. I therefore made a cylinder of gilt paper about 20in. long and 4in. in diameter, this I provided at each end with a bail for suspension, thus, the suspending wire being 8ft. or 10ft. long, the lower end of a short wire dipping into a mercury cup as shown (*ce figure*). With this arrangement



a decided evidence of twist could be noticed, but on account of the resistance of the gilt paper, a strong current could not be used without so high a voltage that the paper took fire several times. I then had a thin copper cylinder made of nearly the same dimensions and suspended in a similar manner, and could use a current of thirty or forty amperes. The rotary motions were in the same directions as before, namely, when the current was going down, the twist was always right-handed as indicated by the arrow, and of course opposite when the current was reversed. While there was no doubt about the rotary movement, the weight of the apparatus was so great, I concluded to see if one made of lighter material—aluminium—would not give greater amplitude with the same current. A similar cylinder of aluminium foil was prepared and so hung that all tangential movement would be due solely to itself, and not at all to any other part of the apparatus, that is, it was mounted with bifilar suspension. The weight of the foil with its connections was 1·85oz. 55·6grams. A bit of mirror was fastened to the upper end, and a beam of sunlight reflected from it upon a scale 16ft. distant and 25ft. long. With this arrangement the twist produced by the current was such that it was not difficult, by timing the swings and changing the direction of the current, to make the cylinder swing through

* Abstract, from the *Electrical World* of New York, of a Paper read before the American Institute of Electrical Engineers.

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90deg. A current of 15 amperes swung it through a foot and a half on the scale. It would come to rest at about half the distance of the greatest amplitude of the swing for each different current employed, and *therefore showed the continuous action of the torsional force for a constant current.* If this be the interpretation of the phenomenon, then the molecules are rotating when there is a constant current, and thus the explanation of the heating effect of the current is brought back to dynamical and mechanical principles. Adjacent molecules must be rotating in opposite directions at their point of contact, but this vibrating or heat motion necessitates more or less separation when such rotation goes on; on impact, it is arrested, so there must be impact and slip, the arrest of motion being the immediate antecedent of the heat, as is friction in any case. These experiments have not been carried out quantitatively for lack of facilities. May be the interpretation is wrong, and some wise one who knows all about it can point out its inadequacy. I think the experiments are new, and may lead to an understanding of what goes on in a conductor when a current of electricity traverses it, if this be not the whole of it.

In the discussion which followed the reading of this Paper, Mr. Mailloux said that he thought the horizontal component of the earth's magnetism might have a great deal to do with the rotation. A wire or a cylinder situated as this is in the earth's field would have present in it Hall's phenomenon, that is to say, the current would not be distributed equally throughout the mass of that cylinder. He thought that this might be a partial explanation of the observed rotation.

Mr. Wolcott did not think that the earth's field would cause continuous rotation if the tube were perfectly straight and perfectly uniform in resistance.

Dr. Pupin called attention to an experiment made some years ago by Prof. Braun. He found that a wire made of a magnetisable substance when twisted one way would generate an E.M.F. in one direction, and if twisted the opposite way it will produce an E.M.F. in the opposite direction.

Mr. Binney suggested that the cause of rotation may be due to the fact that there was more current in one of the bails than in the other, owing to the tendency to lateral shifting in the magnetic field.

Prof. Crocker suspected a lack of symmetry, stating that if the cylinder were a little thicker on one side than on the other, the current would be stronger on that side. If it were perfectly symmetrical he claims that according to our present knowledge of electrical currents there would be no tendency to rotate.

Mr. Carl Hering suggested that interesting results might be obtained if the conducting cylinder were surrounded by a fixed iron cylinder. This would shield it from the earth's field, and if the motion were due to the magnetic lines circulating around that conductor the effect would be increased because the iron cylinder increases these lines.

MEASUREMENTS OF THE HYSTERETIC LOSS OF MAGNETIC ENERGY IN NICKEL.*

BY A. E. KENNELLY.

The energy absorbed in hysteresis by substances under reversals of magnetisation is probably measured most conveniently by the use of a wattmeter with an alternating current. This method cannot be employed when the Ewing H B diagram, or the relation of flux to field, is required, but where only the integrated area of that diagram or the hysteretic energy per cycle is needed for definitely varying maximum flux densities, the convenience, swiftness, and precision with which the observations can be carried out give it great advantages.

Measurement was made of the hysteretic loss of energy in two samples of good commercial nickel wire, each wound up in a coil or Faraday ring. The connections are shown in the Fig. 1. P and S are the primary and secondary coils of a transformer operated by an alternator with an average and nearly uniform frequency of 141·6 ∿. The regulation of the alternator fields controlled the E.M.F. in the coil S, whose circuit was closed through the ammeter A, the fixed coil of a dynamometer wattmeter D, and the insulated winding of the nickel wire ring R. The suspended coil *c* of the dynamometer was permanently connected through an adjustable resistance *r* across the terminals 1 and 2 of this ring. Before and after each wattmeter observation the Weston alternating-current voltmeter V was also connected to the terminals 1 and 2, and a reading of the pressure taken.

The dynamometer was a nearly dead-beat, unifilar torsion instrument, read off by telescope, mirror and scale. Its suspended coil having eight ohms and three millihenrys, in circuit with the resistance *r* of from 1,000 to 6,000 ohms according to the pressure, it is evident that the error in the readings due to lag in the suspension circuit was negligible. The instrument was also sensitive, and gave about 20deg. of twist per watt of indicated power.

It is worthy of remark that the use of such alternating current wattmeters has been often avoided on the ground of inductance error, but when made with sufficient sensitiveness to need only small inductance with high resistance in the suspension circuit, the charge is unfounded, and their indications in power measurements become reliable. For if *c* be the current passing through the fixed

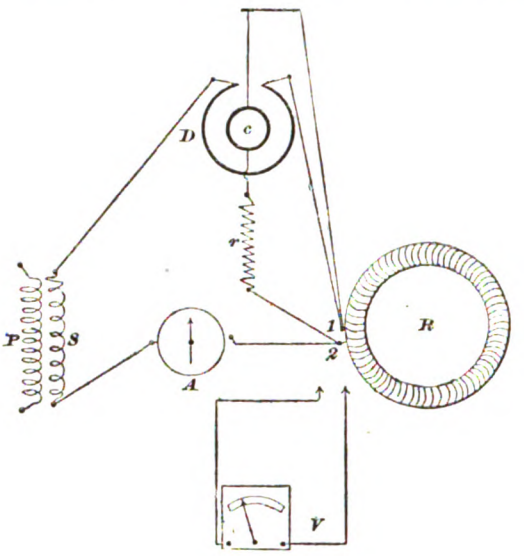

FIG. 1.

coil, and *s* that in the suspension, under an effective pressure *e* through a large resistance, *r*, with a total inductance, *l*, the maximum error in watts that *l* can effect in the readings with a pulsation, $p = 2\pi n$ is,

$$r\,s\,c \sin \tan^{-1} pl/r, \ldots \text{ or very nearly } \ldots e\,c\,pl/r.$$

In other words, the maximum error would be the apparent watts or product of volts and amperes multiplied by pl/r, while the actual error is generally much below this limit.

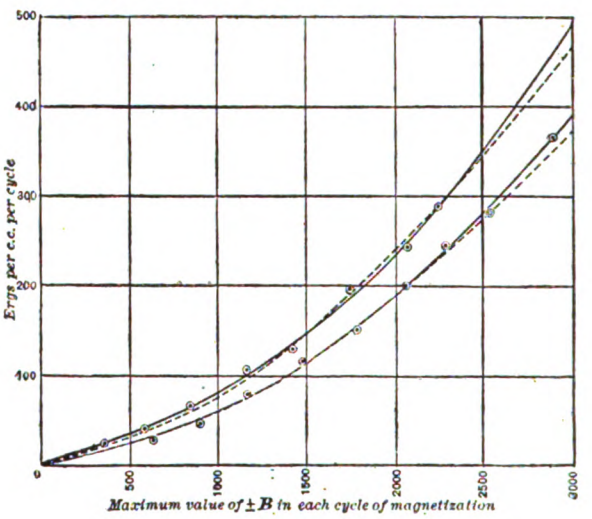

FIG. 2.

The particulars of the rings are given in the following table. The weight of nickel in each was the same, but the diameters of the nickel wires were different. The winding of insulated copper wire was also the same on each :—

Coarse Wire Ring.	*Fine Wire Ring.*
Turns of wire 570	between 4,000 and 5,000
Diameter of wire ..... 0·0365″ 0·0927 cm.	0·0126″ 0·032 cm.
Sectional area of wire ..... 0·006749 sq. cm.	0·000804 sq. cm
Weight of wire in ring ..... 2,255 gms.	2,255 gms.
Volume of wire in ring ..... 253·3 c.c.	253·3 c.c.
Cross-Section of Ring.	
By number of wires..... 3·848 sq. cm.	
By external dimensions ..... 3·852 „	3·852
Mean diameter of ring ..... 20·93 „	20·93 cm.

Winding ..... 700 turns of copper wire on each ring.
Resistance of winding at 18° C. ..... 2·815 ohms.

* From the *Electrical Engineer* of New York.

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Before applying the copper wire winding to these rings, they were well soaked in melted paraffin wax, with the object of limiting all eddy currents as much as possible, although previous tests on the rings without this precaution do not by comparison show appreciable loss from eddies when the bare nickel wire was used. Some 200 grammes of paraffin wax was absorbed into the rings.

In reducing the measurements, the wattmeter readings were corrected for the extra incidental losses of power, namely, e^2/r in the suspension circuit, and c^2 R in the ring. The balance gave the loss in hysteresis assuming no loss in eddies. The voltmeter pressures at ring terminals reduced by c R gave the counter E.M.F. of the ring, from which the maximum flux density in the nickel was determined on the assumption of a simple harmonic E.M.F.

The accompanying curves (Fig. 2) show the resulting ranges of hysteretic loss per c.c. of nickel for the two rings at varying flux densities. The loss is nearly 25 per cent. greater in the coarse wire. The curves agree very fairly, however, with the law of $\frac{5}{3}$ exponent, as lately enunciated by Mr. Steinmetz* for iron, the dotted lines representing the locus of this exponent drawn from the datum point for $B = 1{,}500$ on each curve. The hysteretic loss in ergs per c. c. per cycle for the coarse wire is thus apparently $0{\cdot}00125\ B^{\frac{5}{3}}$ for the coarse wire, and $0{\cdot}00101\ B$ for the fine, between the limits of 0 and 3,000 of maximum cyclic flux density.

There are two reasons for believing that this difference between the absolute values of the hysteretic loss in the two rings was not due to eddy current influence: 1st, that, as above mentioned, the loss of energy was not found to increase when no paraffin was used to insulate the wires; and 2nd, that eddy current influence would introduce a term varying as B^2, and the resulting curve would diverge from a curve of $B^{\frac{5}{3}}$.

The hysteresis was quite definite in each ring, and any reading could be reproduced at will, by adjusting to the right pressure at the voltmeter. Eight series of measurements were made in this way at different times, four series on each ring. The results seem to show that, approximately at least, the hysteresis in nickel varies, as in iron, with the $\frac{5}{3}$ power of the maximum flux density, although the difference in the coefficient would indicate some latitude in the amount of hysteretic dissipation with different specimens. As with iron, therefore, doubling the flux density in nickel practically trebles the hysteretic loss.

The writer is indebted to Mr. A. Hoopes for assistance in carrying out this measurement at Mr. Thomas A. Edison's laboratory.

THE TELEPHONE AT HOME AND IN THE FIELD.†

BY MAJOR C. F. C. BERESFORD, R.E.

After a brief glance at the history of the telephone the author proceeded to describe some of the instruments and appurtenances at present available in the military service. The "Ader" receiver, he said, could be used without a microphone, on short lines, as a speaking instrument, but was only of very moderate power when so used. Its great value, however, appeared when in combination with the instrument familiarly known as the "vibrating sounder," or "buzzer," a system introduced some years ago by Major Cardew, which enabled communication to be held under circumstances when every other form of telegraph would fail. The "buzzer" might be called the backbone of British field telegraphy. When a microphone was added, the combination could then be used at will for speaking, or for communication by Morse signals. The "Ader" apparatus complete, *i.e.*, telephone and microphone, was one of the best at present existing for speaking purposes. It had given excellent results during the last year at Aldershot for work between the various temporary camps, on the new Ash ranges, and on the "Exchange" systems during the manœuvres. It was not so portable as the "Operators" telephone, but spoke louder. The "Berthon" microphone was of a very portable form, useful for telephones in forts where the firing of heavy guns was apt to break the carbon pencils in the other pattern of microphones. The "Operators" telephone was a combination of the "Berthon" microphone and the "Ader" receiver, the two being fixed to one handle. The "Siemens-Halske" pattern had been used a good deal in foreign armies. The "Aubry" telephone, from experiments at Aldershot, appeared to give as good, if not better results than the "Ader" receiver. It was the pattern used in the French army. The "reed" form of call, being the simplest, would seem to be that most suitable for the future development of telephones for outpost work.

It might appear, at first sight, that, in matter of pace, a telephone used for speaking had great advantage over one used for Morse signals, or over a telegraph instrument. But practically for written messages the pace was limited to the writing pace of the receiving clerk. Although the human voice could send a message at the rate of from 150 to 200 words per minute, and although this might possibly be received on a good telephone, it could not be written down except by shorthand. From practical experience at Aldershot, when in some of the Divisional Offices both telegraph and telephone were working side by side, there was no doubt of the great superiority of the sounder over the telephone circuits for carrying traffic. On the other hand, the telephone circuits required little or no special qualifications for the clerks employed, while, for the military sounder clerks, picked men and a training of from four to six or nine months were necessary even for second-class officers. A way of increasing the carrying power of ordinary telegraph lines would be—(1) Improved telephones; (2) a more wide-spread instruction in shorthand writing. The telephone, as a speaking instrument, in its present state, was rather more suited for conversation than for the transmission of important military orders, at any rate in the field. For use on the main line of communication, or for outpost duty, except under exceptional circumstances, the effective use of the telephone for speaking was doubtful.

Attention might be next directed to the consideration of circumstances under which the telephone can be profitably employed for army purposes.

These might be generalised under the following headings:—

(1.) Telephones and exchanges in garrisons.
(2.) For coast defence, including artillery, submarine mining, and general purposes.
(3.) On rifle ranges.
(4.) On artillery ranges.
(5.) For siege operations.
(6.) Main lines of communication in the field.
(7.) Intercommunication in camps.
(8.) Outpost duties.

For garrison work the use of the telephone was obvious; it was employed at all our garrisons and dockyards at the present moment, and its great extension was merely a matter of time. As to the telephone for coast defence, he had no personal experience. During the spring of 1891 telephone lines were erected along the three new rifle ranges at Ash, near Aldershot; the instruments used up to the present time were "Aders"; these had given such good results that the extension of the system to all ranges might be confidently looked for. Colonel Lyons, the Commandant at Lydd, had made a series of valuable experiments with various forms of telephones for use in directing artillery fire at siege operations, and for observing and plotting results. He had come to the conclusion that the telephone as a talking instrument was not reliable for this purpose, but when used in combination with the vibrating sounder it did excellent work.

For work on main lines of communication the telephone, as a talking instrument, would not be of much service. In the first place, it would not carry the traffic which we were accustomed to, and, to give it fair play, it should be served by a well-insulated line, with double wires if on the same poles as other lines. These conditions were frequently impossible on long field lines. At the same time, occasions would often arise when it might be desirable for commanders in the field to hold direct communication by telephone, and arrangements for accomplishing this at will should always be made. The Belgian system, introduced by Major Waffelaert, admitted of a telephone and telegraph instrument being used simultaneously on the same circuit, without interfering with each other. We had in the British army an appliance known as a "separator," which accomplished the same purpose; but it had not, as yet, come into general use, although it had a promising future before it.

As an example of what the telephone might be expected to do on a long field line, he might mention the experiments carried out during the summer exercise of the 1st Division Telegraph Battalion last year. A field line 70 miles in length was run between Aldershot and Chatham, and on many occasions was used for telephone work. The line, running as it did through woods and narrow lanes where contacts with trees and hedge-rows were unavoidable, was a very leaky one, but did not prevent the telephonic communication being carried on with fair success. The instruments used were the "Ader" and the "Operators" telephone, and on the occasion of a ball which took place at Chatham animated conversation was kept up between the guests and some officers at Aldershot. The "Ader" appeared to give the best results.

The first military telephone exchange was established in Portsmouth garrison, over ten years ago. That at Aldershot was not established until within the last five or six years, but was now crowded with work. Plymouth followed suit some three years back, and the Curragh is meditating on the subject. The naval dockyards had all, long since, had telephone exchanges. The appliances of modern civilisation were of slow growth in the British army, but they came in the end.

During the summer manœuvres of last September, in Hampshire, exchanges were established in the camps of the two divisions, being

* "On the Law of Hysteresis," a Paper by Mr. C. P. Steinmetz, read before the American Institute of Electrical Engineers, Jan, 19, 1892. See *The Electrician*, February 12th, *et seq.*

† Abstract of a Paper read before the Royal United Service Institution.

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the first instance, it is believed, of anything of the kind having been tried in the field. The exchanges were in constant work during the manœuvres, and the valuable results obtained might be judged of by the favourable opinions expressed by commanding officers. The consensus of opinion left little doubt of the efficacy of a telephone exchange for camp work, or of the probable demand there would be in the future, and, considering the simplicity of the apparatus needful, there would appear to be no great obstacle to its adoption universally. The question reduced itself to that of the men available for the erection and maintenance of such exchange systems. On home service, the telegraph battalion could often manage to provide them ; but on active service, when the whole of the energies of this body would be devoted to the lines of communication, telephone exchanges might go to the wall. It then remained to be considered whether the advantages to be gained would warrant the necessary equipment being carried and maintained by regiments.

Taking it for granted that the R.E. could provide the exchange switch, which would be erected alongside the telegraph office, the following equipment would be necessary for each regiment :—

1 telephone complete, with microphone transmitter.

1 magneto call.

1 small battery.

Half a mile of cable on a drum, weighing about 50lb.

A few small stores.

Thus equipped, a regiment would, as soon as its camp was pitched, lay its own cable up to the exchange office, where it would be attached to the switch by the telegraph battalion. The original outlay for such an equipment would be about £20, with an annual expenditure of, perhaps, £5 ; and even if this was doubled, the total amount would bear favourable comparison with the cost of one soldier, while it would probably set free the services of several. The carriage of the stores would be trifling ; there would not be more than what two men could carry with ease, the cable being on drums similar to those in use by foreign armies.

Under the head of outpost telegraphs there might be also included all light telegraph work in advance of an army. Whether in repair and utilisation of the lines of the country, temporary lines for local purposes, lines in connection with reconnaissances, or arrangements for tapping the enemy's wires. During the American war the telegraph went ahead of all troops, with or without escort, generally the latter. During the Franco-German War the telegraph work was frequently pushed ahead beyond the cavalry screen, and specially escorted for the purpose ; such was the necessity in warfare of at once gaining communication to the front. Continental Powers were equipping their cavalry with the telephone and telegraph, but it was to the former that the greatest attention was being given. It might now appear to us time to inquire whether we should not be moving in the same direction.

We were not now uncertain of our field lines, as we were in years gone by, when our equipment was of inferior material. There was now a cable in our service, weighing 70lb. per mile, that would stand a strain of 500lb., that had frequently been passed over by artillery and remained intact. In the vibrating sounder we possessed an instrument which in combination with a telephone would transmit signals through bare wires laid on the ground, and even in water. It rested, then, with those in command to say whether such means of communication as had been described would be useful on outpost duties. Whether occasions would not arise when to be able to speak between main body, reserve, and picquets might not be of infinite value. Whether the establishment of some detached post might not entirely depend on the facility of communicating with it. Whether the fact of being able to communicate immediately with the chief points of an outpost line would not reduce the number of men necessary for outpost duty. Whether the knowledge that communication was open throughout would not give confidence to the soldier. And finally whether the mere fact of lines of cable, radiating from certain centres, would not be of great use, especially at night, as providing guides for reinforcements and the like.

Then as regards the cavalry : should they not be in a position to tap an enemy's line (which could be done with the telephone), or to complete and work a deserted circuit, when the local instruments would probably have been taken away ? Or to run short lines for connecting their headquarters with certain points, or with the head of the advancing main line of communication ?

It was as a Morse receiver that the author looked for the best results from the telephone. But this would require trained clerks. Any intelligent man, with a good ear, could in a few months be taught to read sufficiently well for most practical purposes connected with military local work. Many become fair operators in six months. Most regimental signallers who passed through the Signalling School at Aldershot acquired there a fair knowledge of reading by sound, and it would be to those to whom the charge of regimental telephones would naturally fall.

In France the question of outpost telegraphs had been well to the front for some years. France had taken the lead from the time that she saw what the telegraph effected in the war of 1866, and ever since that period she had striven to get the most out of the products of science.

Germany had had for some years the Buchholz-Siemens system for outpost telegraphs. A combined telephone and microphone similar to that introduced into our service had lately been adopted. There was a strong prejudice in Germany against the use of the telephone, on account of its not recording the messages.

In Belgium Major Waffelaert, the Officer Commanding the Telegraph Corps, was a strong advocate of telegraphs for outpost work, and had devoted much time and thought to the subject. The system he had adopted for the Army telegraphs was that known as "Rysselberghe's," whereby it was possible to use, at will, the telephone and telegraph instrument, simultaneously or otherwise, on the same circuit. Major Waffelaert considered that Morse signals were not adapted for outpost work, on account of the difficulty of obtaining trained clerks.

Italy had been disposed to use telephones for military work more than any other country. She was the first to make use of the vibrating armature for giving signals, and also made use of the Morse key, in combination with the telephone. In Spain, owing to the mountainous character of the country, the whole telegraph equipment was of the lightest description, and carried on pack animals.

A statement of what might be expected from the telephone in its present development having been made, and suggestions made as to its employment, it only remained, said the author, to touch on certain drawbacks attending the use, or rather the improper use, of both telephone and telegraph, classing the two together under one head. In a recent article published in the *Proceedings* of the United Service Institution it was stated that "the employment of this technical auxiliary in the first line restricts the high mobility of present warfare." It is possible, and even probable, that the telephone would often create unnecessary correspondence. The ease with which communications could be held would offer temptation to the more feeble to seek the shelter of non-responsibility, to the wavering increased facilities for vacillation, and to some others improved openings for making their presence (in the spirit) felt when least desirable. All this, no doubt, the writer had in his mind—in fact, he saw centralisation encouraged by the telephone. But there was another side to the picture. In a very remarkable article published by the Institution in 1887, and entitled the "March and the Battle," the following gave the keynote :—"The little influence thus possessed by the Commander-in-Chief in choosing the occasion for decisive action is really an element of great difficulty in the warfare of the present day." The whole of the article appeared a most forcible argument, unintentionally, but unmistakably, showing the necessity for a wide extension of the telegraph. The urgent demand for that unity of action almost, if not altogether, lost under the conditions of modern war ; "a great united effort instead of a number of isolated blows." The history of the telegraph was a series of brilliant records of its achievements. "Technical art is striving hard to discover fresh means for enlarging the influence of those in supreme command," and the telephone was its latest effort.

CORRESPONDENCE.

COMPOUND WINDING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : It may be of interest to mention that the four compound-wound dynamos designed by Mr. Gisbert Kapp, and built and erected by Messrs. Crompton and Co. in 1882 at Berechurch Hall, were successfully run in parallel. As the load varied, each machine was switched on or off to a common pair of mains, and reversal guarded against by the now well-known method, at a "parallel switch-board." I am unaware to whom the credit of originating this arrangement is due. Another less important feature was the employment of a main reversing switch for changing the polarity at the mains, with the idea of lengthening the life of the lamps, then, as now, a burning question. There was also an effectual mechanical device which enabled the governor to pull up the engine to something below its normal speed on the sudden removal of a heavy load, such as would be caused by a main fuse melting, or the failure of main driving belt. Altogether it may fairly be claimed that this pioneer installation was more than "up to date."—Yours, &c.,

J. W. KEMPSTER.

Belfast, April 18, 1892.

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TRADE NOTES AND NOTICES.

Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1892.

The tenth annual edition of the above well-known annual is now ready, price 7s. 6d.; post free, in the United Kingdom, 8s. 3d.; abroad (with the exception of a few countries), post free, 8s. 10d.

The edition consists of between 900 and 1,000 pages, and special care has been taken to make the Directorial division of the book, which has been considerably extended, thoroughly accurate and reliable. In this respect no possible comparison can be made with any similar publication.

To the Handbook division has been added several features which will be found of service to the Electrical and Allied Trades. The Digest of the Law of Electric Lighting has been thoroughly revised and brought up to date, and the most recent Board of Trade Regulations are also included. The various tables and tabulated statements have been remodelled and amplified; and a new feature is the tabulation of valuable information respecting Electrical Limited Liability Concerns.

The profession will find "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK a trustworthy work of reference, and purchasers of plant and apparatus may confidently turn to its pages for the names of all the principal firms supplying their requirements. Nearly every firm of any standing in the Electrical and Allied Trades is represented in its advertisement pages.

A digest of the contents of the book will be sent on application.

TENDERS INVITED.—The Gas Supply and Electric Lighting Committee of the Town Council of Glasgow are inviting tenders for excavating, trenching, and the laying of cast-iron troughs for electric conductors. Tenders, duly marked, have to be in by Tuesday next, the 26th inst., to Sir. J. D. Marwick, City-chambers, Glasgow.

TENDERS ACCEPTED.—The tender of Messrs. Hammond and Co. has been accepted for laying down the electric plant for the public supply of electricity at Burton-on-Trent.

——— The Nottingham Castle Museum Committee have accepted the tender of the Brush Electrical Engineering Company (Limited) for the electric lighting of the new Art Gallery in the Castle by incandescent lamps. 18 tenders were sent in.

PARTNERSHIPS DISSOLVED.—The partnership previously existing between Rammage, Gordon and Co., of Victoria Mansions, Victoria-street, S.W., engineers, has been dissolved. The debts of the firm will be paid by Mr. C. G. Gordon.

——— The partnership existing between Messrs. Blakeney and Rennie, of Glasgow, mechanical and electrical engineers, has been dissolved. Debts will be paid by Mr. J. Rennie.

MUIR, MAVOR, AND COULSON (LIMITED).—We are asked to point out in reference to the voluntary liquidation of the above Company that this does not in any way affect the contracting business carried on by Messrs. Mavor and Coulson at 56, George-square, Glasgow.

ELECTRICAL AUTOMATIC DELIVERY BOX COMPANY (LIMITED).—Mr. F. G. Painter (of the firm of Tribe, Clarke, Painter and Co.), the official liquidator of this Company, will, with the sanction of Mr. Justice Kekewich, pay a first and final dividend of 1s. 8½d. per share on and after the 19th inst., at his offices, 19, Coleman-street, E.C. Creditors have previously received 20s. in the £.

CITY OF LONDON ELECTRIC LIGHTING (PIONEER) COMPANY (LIMITED).—In the matter of the voluntary winding-up of this Company, a meeting will be held at the offices, 1 and 2, Great Winchester-street, London, E.C., on the 19th May next, at 3 o'clock, for receiving an account of the winding up.

REMOVAL.—The Pretoria Lighting Company's London transfer office has been removed to 29, Holborn Viaduct, E.C.

DIVIDENDS IN BANKRUPTCY.—A second and final dividend of 2s. 5¾d. in the £ will be paid at the offices of Mr. C. J. Singleton, 8, Staple Inn, E.C., on April 29th, in the matter of J. W. Gray and Son, Electrical Engineers, &c., of 115, Leadenhall-street, E.C.

CHICAGO EXHIBITION, 1893.—We again call attention to the fact that the Royal Commission are now enabled to announce that no charge will be made for space in the British Section. Intending exhibitors should lose no time in applying for space to Sir H. Trueman Wood, Society of Arts, John-street, Adelphi, W.C.

ELECTRIC SOLDERING, &C., APPARATUS.—Messrs. Pyke and Harris are showing at the Weymersch Electric Battery Syndicate's Stall No. 113, at the Crystal Palace, an electrical apparatus for soldering, boiling, or heating, the invention of J. K. Ritter of Basle.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

March 29, 1892.

6,112. H. H. LAKE. London. Improvements in and relating to secondary batteries or accumulators. (W. Sleicher, Jun., and G. A. Mosher, United States).

6,119. M. CATTORI. London. Improvements relating to electric railways

March 30, 1892.

6,122. E. C. RUSSELL. London. An improvement in the construction of electric arc lamps.

6,145. E. M. BOYNTON. London. An improved electric railway system.

6,152. T. FIELD, JNR., J. WORSFOLD AND H. S. D. BRAYN. London. An improved material or fabric for applying magnetic, galvanic or other currents for curative or medical purposes.

6,181. L. G. WOOLLEY. London. Improvements in or relating to automatic electric fire-alarms.

March 31, 1892.

6,246. W. W. BEAUMONT. London. Electro-magnetic variable speed gearing.

6,253. A. S. CHURCHILL. London. Improvements in apparatus for propelling vehicles by electricity upon railways and tramways.

6,259. E. BAILEY. London. Improvements in the manufacture of filaments and other light emitting bodies for electric glow lamps and apparatus therefor.

April 1, 1892.

6,287. E. BÖHN. London. Improvements in incandescent lamps.

6,289. J. C. GRAHAM. Birmingham. Improvements in the deposition of metals by electrolysis, and in apparatus therefor.

6,293. J. GIBSON. Kilmarnock. Improvements in motors and dynamos.

6,312. C. W. HILL AND E. HUGHES. Manchester. An electrical apparatus for starting gas engines and other prime movers.

6,313. T. G. HARTLAND AND J. EVANS. Manchester. Improvements in receptacles for electric and other wires, gas piping and the like.

6,344. C. J. BARLEY AND M. FEETHAM. London. Improved apparatus for straining or taking up slack in wires, cables, strips, or the like, more especially intended for straining electric conductors between their supports.

6,345. H. NEHMER. London. Improved electric hammer for denta and other purposes.

6,348. W. S. SMITH AND W. P. GRANVILLE. London. Improvements in electrical relays.

6,364. H. H. LAKE. London. Improvements in electric arc lamps. (H. Wilbrant, Belgium).

April 2, 1892.

6,402. G. FORBES. London. Improvements in the means of preventing interference of electric currents used in tramways, telephones, &c.

6,405. D. URQUHART AND J. M. SMALL. London. An improvement in secondary voltaic batteries.

6,428. E. HANCOCK AND A. J. MARQUAND. London. Improvements in the manufacture of elements for electric or secondary batteries.

April 4, 1892.

6,465. G. E. HEYL. London. Improvements in electrical secondary or storage batteries.

April 5, 1892.

6,551. C. L. JAEGER. London. Improvements in electric recording devices for mariners' compasses and other instruments.

6,569. J. E. KINGSBURY. London. Improvements in telephone cables.

6,579. M. DERI. London. Improvements in alternate-current electro motors.

April 6, 1892.

6,629. SIEMENS BROS. AND CO., LIMITED, AND F. JACOB. London. Telephone call apparatus.

6,635. A. S. BOWER. London. Improvements in or connected with moulds for casting ribbed metallic plates; more especially intended for use for casting plates for secondary batteries.

6,637. G. E. HEYL. London. Improvements in electrodes for storage batteries.

April 7, 1892.

6,688. C. D. RICHARDSON. London. An automatic self locking quick break switch.

6,694. G. J. SPALDING AND R. L. HAWKINS. London. Improvements in electric hair and skin brushes.

6,693. H. G. JACKSON. London. Improvements in and relating to dynamo-electric machines, electric motors, continuous-current transformers, and the like.

6,705. G. HUGHES. London. Improvements in insulators. (B. V. Vermorel, France.)

6,707. G. KAPP. London. Improvements in the method and apparatus for registering supply of electricity.

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6,720. J. A. Kingdon. London. Improvements in dynamo-electric machines.
6,722. W. W. Donaldson and R. Macrae. London. Improvements in battery plates or secondary batteries.

April 8, 1892.

6,725. G. E. Tucker. London. The manufacture of electrical fires.
6,726. R. Pippette. London. Improvements in multiple switchboards for telephone exchanges.
6,775. T. Higginson-Wolstencroft. London. A new or improved electrical apparatus.
6,785. L. B. Stevens and W. R. Sykes. London. Improvements in electrically controlling the levers of railway signal interlocking apparatus.

April 9, 1892.

6,839. J. E. Bott and C. G. Norris. London Improvements in means for electro-plating the interior of tubes and other hollow articles.
6,861. G. Binswanger. London. Improvements in electrical heating apparatus.
6,868. R. C. Kintzing. London. Improvements in dynamos or motors.
6,870. A. D. Monies. Liverpool. Holding telephone receivers (viz., that part of a telephone through which the communication is heard) against the ear.

April 11, 1892.

6,888. W. L. Spence. Manchester. An improved conduit system for electric conductors.
6,911. W. J. Davy. London. Improvements in change over mechanism for electric arc lamps.
6,954. R. J. Crowley and W. Walker. Liverpool. Improved means of producing motive power and electricity.
6,961. A. Heil. London. Improvements in automatic switches for electrical apparatus.

April 12, 1892.

6,989. J. A. McMullen. London. Improvements relating to conduits, applicable for combined use as casings for electrical conductors and for gas supply, or for either use separately.
7,003. R. J. Charleton and H. Walker. London. Improvements in coal-cutting machines, with special reference to electrical motive power.
7,004. A. Wallace. London. Improvements in electrical cooking apparatus.
7,008. W. A. Heyes. London. Improvements in electric light fittings.
7,009. H. Skipper and H. J. Pierce. London. An improved telephone transmitter.
7,016. J. McFarlane and W. B. Edgar. Glasgow. Improvements in electric fittings.
7,029. G. G. M. Hardingham. London. Improvements in electric cables.
7,037. R. Belfield. London. An improvement in electric arc lamps.
7,044. E. J. Wood. London. Improvements in dynamo-meters.
7,081. J. D. Hickman. London. Improvements in telephone and electric signalling circuits between trains and signal boxes.

April 13, 1892.

7,095. J. Sugden and W. J. L. Sandy. London. Improvements in electric arc lamps.
7,126. A. Wright. Brighton. Improvements in electrical distribution.
7,142. E. A. Kruger. London. An improved method of renewing incandescent electric lamps.
7,144. G. H. Cutting. London. Improvements in secondary batteries.

April 14, 1892.

7,170. T. E. Weatherall. Greenwich. An improvement in primary batteries.
7,172. S. R. Bradley. London. Electrical surgical instruments.
7,173. A. Whalley. Helsby. An improvement in electric signals.
7,206. A. A. Voysey. Liverpool. Improvements in or connected with connections or couplings for electric and other cables and ropes.
7,220. F. B. Stone. Belvedere. An improved primary battery.
7,235. R. J. Charleton and H. Walker. London. Improvements in coal-cutting machines, with special reference to the application of electrical motive power.
7,237. B. S. Paterson and J. B. Furneaux. London. Improvements in commutators for electrical machines.
7,252. R. E. B. Crompton and W. A. Chamen. London. Improvements in electrical distributing apparatus.
7,253. T. Duffy. London. Improvements in generating electricity and producing air in a luminous state, and in apparatus therefor.
7,264. H. T. Harrison. London. Improvements in electric arc lamps.

April 16, 1892.

7,275. H. W. Miller. London. Improvements in electric meters.

SPECIFICATIONS PUBLISHED.

All Specifications price 8d.

1891.

3,570. George. Electrotherapeutic apparatus.
4,794. J. E. Kingsbury. London. Signalling and telephonic systems.
5,338. Crampton and Essinger. Electric arc lamps.
5,989. Lancaster. Electric lighting.
6,633. Teagut. Electric meters.
8,031. Howard. Electric heating, &c.
8,126. Philpott. Dynamo-electric machines.
8,378. South. Electric current circuits.
8,450. Snell. Connecting electrical conductors to surgical, &c., instruments.
9,079. Hoeffner. Electrolytic extraction of meta's, &c.
9,423. Grenfell. Electric incandescent lamps.
16,270. Thompson. (Correns). Electric accumulators.
17.655 Burton and others. Heating metals by electricity.
18,290. Lundberg. Electric switches.
22,352. Painter. Electric switches.

1892.

177. Painter. Electric drop lights.
2,254. Thompson. (Fuss.) Incande cent electric lamps.
2,329. Imray. (Montgomery.) Bleaching by electrolysis.
2,330. Gimingham. Electric switches.
2,458. Pool and Others. Dynamo-electric generators, &c.
2,913. Nahnsen. Electro-metallurgic extraction of zinc.
3,542. Lake. (Gray). Telephonic apparatus.

COMPANIES' MEETINGS & REPORTS.

Eastern Extension, Australasia, and China Telegraph Company (Limited).

The following report of the Directors of this Company for the half-year ended December 31st last will be submitted to the thirty-seventh ordinary general meeting, to be held at Winchester House, E.C., on Wednesday, May 4th, at 2 p.m.

The gross receipts, including Government subsidies, have amounted during the half-year to £243,658. 8s. 10d., against £279.095. 1s. for the corresponding period of 1890. In the latter figures, however, £8.031 was included for profit on exchange, whereas a loss of £3,232 had been experienced during the past half-year, in addition to which the receipts have been diminished by the reduction of rates to Australia, to which further reference is made below.

The working and other expenses, including £22,031. 17s. 6d. for cost of repairs to cables and expenses of ships, absorb £74,314. 8s. 5d. against £74,000. 3s. 2d. for the corresponding period of 1890, leaving a balance of £169,343. 19s. 5d. From this is deducted £3,092. 2s. 10d. for income tax, and £31,895 for interest on debentures, debenture stock, and contribution to sinking fund, leaving as the net profit for the half-year £134,356. 16s. 7d. Against this £2,535. 4s. has been charged for special expenditure, as shown in the revenue account, leaving a balance of £131,821. 12s. 7d., which, with £92,665. 9s. 7d. brought forward, shows an available balance of £224,487. 2s. 2d.

One quarterly interim dividend of 1½ per cent. has been paid for the half-year, and it is now proposed to distribute another of like amount, making, with the interim dividends paid for the first half-year, a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent, for the year 1891. The balance of £111,987. 2s. 2d. has been carried to the general reserve fund, which, after being credited with interest and debited with £191,163. 2s. 4d. on account of the cable expenditure, now stands at £428,842. 7s. 4d.

In accordance with the provisions of the Trust Deed, dated May 15, 1879, 337 of the Company's Five per Cent. Australian Government Subsidy Debentures, amounting to £33,700, were drawn by lot on the 4th instant for payment at par on July 1st next.

The "Guarantee" arrangement made with certain of the Australasian Governments for testing the effect of a 4s. rate to Australia has now been in operation for eleven months, with the result that the number of words transmitted has increased 43 per cent over the corresponding period of 1890, and 60 per cent. over that of 1889, the year taken as the basis of the "Guarantee," while the revenue has diminished at the rate of £55,000 per annum. By the terms of the agreement one half of the loss is borne by the guaranteeing Colonies, and the other half by the Associated Companies and the Indo-European Department of Her Majesty's Indian Government, according to their respective interests in the Australasian traffic. As the experiment, as far as it has gone, is considered not unsatisfactory, it has been decided to continue it for another year.

Numerous interruptions have occurred on the Company's system during the past half-year, but owing to most of the cables being duplicated, the traffic has not been materially affected, except with Manila, which was unfortunately cut off from telegraphic communication for several weeks, the cable between Hong Kong and Cape Bolinao having broken at each end of the line during a severe typhoon. Negotiations have since been entered into with the Spanish Government for the duplication of the cable, and it is hoped that a satisfactory arrangement may be shortly brought about. All the cables are now in good working order.

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During the half-year under review the Company's system has been extended to Sumatra in accordance with the arrangement concluded with the Netherlands Government, and referred to in the last report. The cable for this connection was taken from the Company's stock at Singapore, and the cost of the operation (£14,924) has been debited to the reserve fund. A contract has also been entered into with the Netherlands-Indian Government for the manufacture and laying, on account of the Government, of a submarine cable to connect Acheen with the Company's system at Sumatra, and an arrangement has been made with the Telegraph Construction and Maintenance Company for carrying out the work.

The shareholders having at the last meeting approved the principle of establishing a staff pension fund, your Directors are having the details worked out by experienced actuaries, and a scheme will be submitted to the meeting for dealing with the matter, together with a formal resolution empowering the Directors to carry out the necessary arrangements.

In accordance with the Articles of Association, John Denison Pender, Esq., and the Most Honourable the Marquis of Tweeddale retire by rotation, and, being eligible, offer themselves for re-election. The retiring auditors, Mr. Henry Dever and Messrs. Welton, Jones and Co., also offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

ELECTRIC CYCLE SYNDICATE (LIMITED).—This Company was registered on April 12th with a capital of £3,000, in £1 shares, by Goldring, Mitchell, and Phillips, 20, Abchurch-lane, E.C. The objects are to purchase or otherwise acquire letters patent, inventions, rights, and privileges (subject to royalty or otherwise) in connection with electrical or mechanical inventions or improvements, whether in the United Kingdom or abroad; to carry on the business of electrical and mechanical engineers; to buy, sell, manufacture, repair, convert, let out on hire, trade and deal in electrical and mechanical appliances, and all or any kind of apparatus or appliances used in connection therewith; and to experiment and test with the object of propelling cycles and other vehicles by means of electricity, and for the purpose of utilising electricity for any or every other purpose. Registered without Articles of Association.

ORIENTAL TUBE COMPANY (LIMITED).—This Company has been registered with a capital of £30,000, in £5 shares, to acquire the business of engineers and tube manufacturers, carried on by W. W. Davies, at West Bromwich, Staffs., and elsewhere.

BIRMINGHAM HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 11th last, was filed on the 13th inst. The Company, was registered on June 26, 1889, with a capital of £100,000, divided into 19,900 ordinary and 100 founders' shares of £5 each. At the time of making-up, 107 shares (100 founders' and 7 ordinary) had been taken up, of which the founders' shares had been issued as fully paid to the House-to-House Electric Light Supply Company (Limited). Upon the remaining 7 ordinary shares no calls have been made.

Lancashire and Cheshire House-to-House Electricity Company (Limited).—The annual return of this Company, made up to January 11th, was filed on the 13th inst. The Company was registered on June 26, 1889, with a capital of £100,000, divided into 19,900 ordinary and 100 founders' shares, of £5 each. At the time of making-up, 107 shares (100 founders' and 7 ordinary), had been taken up, of which the 100 founders' shares had been issued as fully paid to the House-to-House Electric Light Supply Company (Limited), similarly with those of the Birmingham Company. Upon the remaining shares no calls had been made. In this and the following six Companies, the shareholders are the original subscribers, and each Company has the same shareholders.

Manchester House-to-House Electricity Company (Limited).—The annual return was made up to January 11th, and filed on the 13th inst. The capital is the same, and the particulars relating thereto are precisely similar to the preceding and following House-to-House Companies.

Midland House-to-House Electricity Company (Limited).—See preceding remarks.

Northern House-to-House Electricity Company (Limited).—See preceding remarks.

Scottish House-to-House Electricity Company (Limited).—See prepreceding remarks.

South of England House-to-House Electricity Company (Limited).—See preceding remarks.

Western House-to-House Electricity Company (Limited).—See preceding remarks.

CORLETT ELECTRICAL ENGINEERING COMPANY (LIMITED). — An agreement made on April 2, 1892, between George Stephen Corlett, of Wigan, electrical engineer, of the one part, and John C. Kenyon, of Wigan (as trustee for and on behalf of the above-named Company), of the other part, states that whereas the said George S. Corlett has carried on the business of electrical engineer in co-partnership with Mansell Mercier for some years past at Wigan and Bolton, and that this partnership has been dissolved as from January 1, 1892, the said George S. Corlett continuing the business; and whereas the above-named Corlett Electrical Engineering Company (Limited) has been incorporated with a capital of £10,000, in £10 shares, it has been agreed that George S. Corlett shall sell, and the Company shall purchase, all the properties, plant, goodwill, &c., of the old firm for the sum of £750, and such further sum as the certified value of the stock-in-trade, goods, and effects. The purchase-money to be satisfied by the allotment of 100 shares of £10 each, fully paid up, to the said G. Corlett or his nominees, and the balance of the purchase-money within one month of the date of the agreement. George S. Corlett is to be Managing Director of the Company for a period of ten years from the date of its formation, with remuneration varying as the paid-up capital of the Company and dividends paid thereon vary. The purchase shall be completed as from March 31st last.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The annua return of the above-named Company, made up to April 5th, was filed on the 14th inst. The Company was registered on November 8, 1872, with a capital of £130,000, in £10 shares; and by special resolution, passed July 3, 1874, and confirmed July 17, 1874, the Directors were authorised to purchase the submarine cable laid between Barcelona and Marseilles; and, for effecting the purchase, the capital of the Company was raised to £190,000 by the creation of 6,000 new shares of £10 each, which were to be entitled to a fixed preferential dividend of 10 per cent. per annum. By special resolution, however, passed September 30, 1886, and confirmed October 19, 1886, it was resolved that, in consequence of the abandonment of the Company's original cable, the capital of the Company should be reduced from £190,000 (represented by 6,000 £10 per cent. preference and 13,000 ordinary shares of £10 each) to £95,000, by the writing off of £5 per share. At the time of making-up (the capital having remained the same), 12,931 ordinary and 6,000 preference shares had been taken up. Upon the ordinary shares £4 per share had been called, and upon the preference shares the full amounts have been called. All calls have been paid, amounting so £81,724.

LIVERPOOL ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 18th, was filed on the 9th inst. The Company was registered on January 10, 1883, with a capital of £10,000, in £5 shares, and by special resolution passed July 10, 1885 and confirmed July 27, 1885, the capital was raised to £200,000 by the addition thereto of 38,000 new shares of £5 each. At the time of making up all the shares had been taken up, and upon 10,000 shares the full amount had been called, while upon the remaining 30,000 shares £3 per share had been called. The calls paid (including £8,243. 10s. paid in anticipation of calls) amount to £148,243. 10s., leaving nothing unpaid.

RAILWAY ELECTRICAL FOG SIGNAL SYNDICATE (LIMITED).—An agreement made Oct. 27, 1891 (filed Feb. 26, 1892), between Wm. Andrews (who is called the vendor), of Nottingham, electrician, of the one part, and Joseph Press, junr., on behalf of the Company, states that the vendor had an interest in letters patent, No. 18,747, of 1889, for "Improvements in railway signalling apparatus," and was owner of the letters patent, No. 14,181, of 1890, for "An improved electrical fog signal for railways;" and it was agreed that the vendor should sell, and the Company purchase, the said patents and the full and exclusive benefit thereof, and of all extensions of the same, and of all improvements and all further inventions in connection with the said letters patent made by the vendor. The purchase consideration for the said sale was to be £9,000, to be fully satisfied by the allotment of 9,000 fully paid-up £1 shares in the said Company. An agreement of the same date gives the Company similar rights and benefits over certain foreign and colonial letters patent, similar in character to the above, for the further consideration of £9,000, in paid-up shares of £1 each in the Company. The Company was registered on November 12, 1891, with a capital of £25,000, in £1 shares, with objects as indicated in the above agreements.

CITY NOTES, &c.

A RUBBER TRUST.—The *New York Herald* announces the incorporation of the United States Rubber Company, having a capital of $50,000,000 The sponsors of the new undertaking are Mr. Charles R. Flint and Mr. Wm. Ivins, who claim that with others they have secured the control of the biggest concerns in America for the production of rubber. The Company was incorporated in New Jersey on the 29th ult., and is established to do a manufacturing and mercantile business. It will manufacture and deal in all kinds of rubber goods. The rubber industry is rapidly developing in the United States of late, and it is claimed that the amount of business has trebled during the past 20 years, and that two-thirds of all the rubber produced in the world is consumed in the States.

ANGLO-ROMAN CAB COMPANY.—At the recent general meeting of this Company in Rome a dividend of 12 per cent. was declared for 1891. The profits of the electrical department for 1891 were £2,000 more than those for the previous year.

BELL TELEPHONE COMPANY.—At the annual meeting of the Bell Telephone Company, held in Boston on the 29th ult., it was decided to increase the capital from £3,000,000 to £4,625,000. The net earnings of the Company were £625,364, against £573,884 for the previous year.

BRIGHTON AND HOVE ELECTRIC LIGHT COMPANY (LIMITED).—This Company are issuing first mortgage debentures of £100 and upwards, up to £15,000.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended April 17th were £734, as against

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£816 for the corresponding period of last year, being a decrease of £82. The total receipts to date, from January 1st last, amount to £12,817, against £11,729 in the corresponding period of 1891, being an increase of £1,088.

DIVIDENDS DUE.—*April 23:* DIRECT UNITED STATES CABLE COMPANY, 3s. 6d. per share (free of income-tax).

GREAT NORTHERN TELEGRAPH COMPANY OF COPENHAGEN.—The balance-sheet of this Company for the year to December 31st last shows gross receipts, including a balance of £48,216 brought forward from the previous year, £359,646, and expenditure £65,448. Interest and amortisation of debentures absorb £21,250, the interim dividend of 5 per cent. £75,000, and a further dividend of 7s. 2d. per share £54,166. A sum of £83,333 has been placed to the reserve fund, and a balance of £56,169 is carried forward. The total assets of the Company now amount to £2,816,255.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the fortnight ending April 15, 1892, amounted to £2,673, as compared with £3,661 in the corresponding period of last year, a decrease of £988.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended April 15, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,746.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, April 12.	Price Wednesday, April 20.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending April 20. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/6	Anglo-American ..... xd	49½ 50½	48½ 49½	5 6 1	Jan., Apr., July, Oct.	..	..
£2,849,510	Stock	25/0	Do. Preferred ..... xd	88½ 89½	87½ 88½	5 17 4	" "	88½	88
£2,849,510	Stock	5/0	Do. Deferred ..... xd	11⅞ 11¾	11 11½	..	" "	11½	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	10¾ 11½	10¾ 11½	7 2 3	Mar., June, Oct., Dec.	11⅛	10 13/16
£68,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)....	104 108	104 108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	155 160	155 160	4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	10½ 11½	10½ 11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½ 3¾	3½ 3¾	6 18 8	April and October..	..	..
6,000	5	10%	Do. Preference 10%	8½ 9½	8½ 9½	5 5 8	" "	..	..
60,710	20	3/6	Direct United States ..... xd	11½ 12½	11½ 11¾	6 1 9	Jan., Apr., July, Oct.	11½	11⅜
400,000	10	2/6	Eastern ..... xd	14⅜ 15	14⅜ 14⅝	4 10 5	" "	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference ..... xd	15¼ 15⅝	15 15⅛	3 17 5	" "	15 7/16	15⅛
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.....	109 112	109 112	3 11 5	May and November	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 109	4 11 9	February & August	107	..
250,000	10	2/6	Eastern Extension	15 15½	15 15½	4 11 10	Jan., Apr., July, Oct.	15 7/16	15
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108 111	108 111	3 12 1	February & August	..	..
£78,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb..1900 ..	102 105	102 106	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)....	99 102	99 102	3 18 5	February & August	..	..
180,227	10	2 6	Globe Telegraph and Trust..... xd	10½ 10⅝	10 10½	5 2 5	Jan., Apr., July, Oct.	10 5/16	10
180,042	10	6%	Do. 6 per Cent. Preference ..... xd	15½ 15⅝	15 15½	3 18 8	" "	15½	15
150,000	10	5/0	Great Northern	18¾ 19½	18¾ 19½	4 8 4	Jan., April, and July	19½	19
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	41 43	41 43	5 16 3	May and November	42½	42⅝
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 0 1	March & September	..	..
9,000	8	4/0	Reuter's	6 7	6 7	5 14 3	April and October..	..	..
3,381	£100 Cert.	22/6	Submarine Cables Trust 6% ..ex 22/6 April coupon	116 121	115 120	5 0 0	" "	117	..
15,609	10	3/0	West African Telegraph	7 8	7 8	6 5 0	January and July ..	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	101½	..
30,000	10	2/0	West Coast of America	3½ 4½	2½ 3½	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102 106	102 106	7 10 11	June and December	..	..
88,321	10	1/0	West India and Panama	1⅝ 1⅞	1⅝ 1⅞	..	" "	..	..
84,563	10	6%	Do. 6 per Cent. 1st Preference.....	10 10½	10 10½	5 14 3	May and November	10 1/16	10⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
67,007	15	6/0	Western and Brazilian	10 10½	10 10½	7 2 10	" "	10⅜	..
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6 6½	6 6½	5 15 3	" "	6⅝	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4 4½	4 4½	..	" "	4	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104 107	104 107	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910..	104 107	104 107	5 12 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118 122	118 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	97 100	98 102	6 0 0	March & September	..	..
			TELEPHONES.						
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance...	⅜ ½	⅜ ½	8 7 7	May and November	..	..
20,000	£1	4·76d.	Oriental (11s. paid)	¼ ⅜	¼ ⅜	6 3 11	Yearly	..	..
438,984	5	2/6	National	4¼ 4½	4⅜ 4⅝	6 9 9	June and December	4½	4½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13½	12⅝ 13½	4 8 11	" "	13⅜	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12 12½	12 12½	4 16 0	" "	..	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	106 108	107 109	4 2 7	January and July ..	..	..
58,000	5	1/0	United River Plate	2 3	2 3	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock.....	85 95	85 95	5 5 3	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
30,152	£10	..	City of London Electric Lighting (£8 paid)	7½ 8	7½ 8	..	—	..	..
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	—	..	..
8,332	£5	..	House to House Electric	.. ..	5⅛ 5¾	..	..	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.)	5¾ 6	.. ..	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	5¾ 6	.. ..	..	January and July ..	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 paid)	2⅞ 3	2⅞ 3	..	March	..	..
10,000	£5	4%	Do. (fully paid)	5 5⅛	5 5⅛	..	March	..	..
111,000	5	..	London Electric Supply	⅞ 1⅛	⅞ 1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8¼ 8¾	8⅜ 8¾	..	..	..	..
6,318	10	..	Notting Hill Electric Lighting (fully paid).....	4 5	4½ 5½	—	..	..	..
18,680	£5	5/0	St. James' and Pall Mall	8¼ 8¾	8¼ 8¾	—	..	8⅜	8 7/16
7,900	£5	7%	Do. 7% Preference	7⅛ 8	7⅛ 8	..	..	7 15/16	7½
62,853	5	..	Westminster Electric Supply (fully paid)	6⅞ 7	6⅞ 7	..	..	6⅞	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	1/0	Brush Electrical Engineering.....	3 3¼	3 3¼	..	..	..	..
69,996	2	6%	Do. 6 per Cent. Preference	2 2¼	2 2¼	5 2 7	..	2¼	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5¼ 5⅜	5¼ 5⅜	5 16 8	January and July ..	5⅝	5⅜
17,130	5	17%	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	12/0	Electric Construction	5⅜ 6½	5⅜ 6½	..	—	6½	5⅞
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅝ 2⅞	2¼ 2½	—	—	2¼	2⅛
20,000	5	..	Fowler-Waring Cables (fully paid).....	2 3	2 3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	19½ 20½	19½ 20½	4 17 7	February & August	20½	20½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 105	102 105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	4½ 5⅛	4½ 5⅛	..	..	..	..
11,334	£10	8/0	Do. Preference	8 9	8 9	8 18 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	6/0 8/0	6/0 8/0	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	3¾ 4½	3¾ 4½	9 0 9	May and November	4⅛	4
36,250	12	36/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 1	March and July.....	43½	..
150,000	100	5%	Do. 5 per Cent. Bonds, red.1894	101 104	101 104	4 16 2	January and July ..	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)..	.. ..	.. ..	4 10 0	..	..	—
—	£5	8%	Do. Preference (fully paid).....	.. ..	.. ..	11 0 0	—	..	—
			RAILWAYS AND TRAMWAYS.						
£2,850	10	7½%	Blackpool Electric Tramway	.. ..	.. ..	—	—	..	..
50,000	£10	—	City and South London Railway	2⅛ 2⅜	2⅛ 2⅜	..	—	..	..

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THE ELECTRICIAN:

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NOTES.

The occasion of the taking up of the nominal load was celebrated at the Regent's Park station of the St. Pancras Vestry on Wednesday last. The engine-room was crowded with visitors, who divided their attention between electric frying-pans and dynamos, some few penetrating as far as the boiler-house, and most of them looking as if they took an intelligent interest in the switch-board. A supply station is not perhaps the most convenient place for an afternoon party; but a visit to the St. Pancras station is a visit to a thoroughly successful concern, and one of which both the engineers and the Vestry may be proud.

The "taking-up" of the nominal load allows the management to estimate the revenue which may be expected from the present supply; and although there was primarily no intention of making a profit, the undertaking has shown a very fair prospect of financial success. Now that the plant is fully occupied at night, endeavours are being made to secure a better day load, and the Electricity Committee recommend that a special day supply should be provided by a separate meter at 3d. per unit. This is cutting the margin very fine if that price be compared with the sheer cost of the present supply; but the plant is there, and steam must be kept up, so that the extra expense besides coal would be very small. There is then every reason to expect that, as long as the day and the ordinary supply do not overlap during fogs and winter afternoons to such an extent as to overload the machinery, the increased revenue will not only pay for the larger output, but will allow the charge for the ordinary supply to be reduced.

Judging by the bulky batch of leaflets which we have received from the New Telephone Company, this rising hope of schismatic and unsatisfied London telephone renters is about to vigorously canvass the metropolis. On the one hand we have this sanguine competitor for our favour *promising* an underground twin-wire and efficient service, with trunk connection to the North, for £14 per annum, the first 5,000 subscribers to be taken on at only £12. 12s., and no charge whatever to be made until 3,000 instruments are actually in connection through the Exchange; and, on the other hand, we have the National Telephone Company, with its £20 subscription and its overhead single-wire much-grumbled-at service. At first glance, therefore, the bait looks exceedingly attractive. But the promises of youth are notoriously not to be relied upon; and the New Company, though old in years, lacks the chastening influence of wide practical experience.

The rates now proposed by the New Telephone Company are already higher than those originally suggested, and apply only to lines within one mile of the nearest Exchange; so that the National Company has only to slightly level up its service and to slightly level down its rates to render serious competition almost out of the question. In any case, the New Telephone Company will have deserved well of the country should it confine itself to "alarums and excursions," and by mere threat of competition lighten the burden of the metropolitan telephoning public. Perhaps, however, the New Company hankers after a more substantial reward. It need not despair even of that, for much is within the reach of the skilful tactician.

Mr. Preece supplies us this week with a striking example of the throttling action of iron pipes when used to protect cables carrying alternating currents. In the instance given, one hundred feet of this cable, when the full load was put on the mains, produced a drop of volts of 13 per cent, or about twenty times that due to the mere resistance of the leads. The publication of the full particulars is opportune in connection with the recent work of Professors Ewing and Thomson on eddy currents, for the fall of volts, large as it is, is not nearly so great as ordinary calculations would indicate, owing to the screening action of the eddy currents formed in the pipe. The thickness of the iron in these pipes was over five millimetres, or more than twice that of the thickest plates alluded to in Professor Ewing's recent article; and it appears that under these circumstances the magnetic force in the middle of the iron was only one-thirtieth of its skin value, and that the mean magnetisation of the pipe was only a sixth of the value it would have if the iron were non-conducting. The only way to reduce these losses for electric light circuits is to place the going and return cables in the same iron pipe, for the thickness of the iron cannot well be diminished. For telegraphic and telephonic circuits the loss of power is of course unimportant, but the need for rapid and clear signalling naturally leads to the same conclusion.

The expressions given by Profs. Ewing and Thomson for eddy current losses are of great value, but they are too

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cumbrous and difficult for rapid calculations, and engineers will accordingly welcome the simple working rule given by Dr. FLEMING in this issue. In transformers, where it is necessary to laminate the iron very thoroughly, it appears that for all practical purposes the losses can be very simply expressed in terms of the thickness of the plates, the frequency of the current, and the maximum induction density used. The divergence of the formula from the actual value probably differs for various types of transformers, but appears to be too small to be worth considering.

THE formulæ of Profs. EWING and THOMSON are explicit; they rely on no unknown coefficients, and are cumbered with no arbitrary constants; they are composed of quantities well known to all electrical engineers, though these quantities are not perhaps handled in a popular fashion. Dr. FLEMING supplements these formulæ by one which may be called implicit, not in the sense of infoldedness and complication, by any means, nor in the mathematical sense; but signifying that it must be tacitly received on the word of its author. Coefficients are indeed conspicuous by their absence; they seem to have cancelled each other. Dr. FLEMING's formula is thoroughly Molesworthy, and is likely to find its way straight into the drawing office.

BY the acceptance on the part of the Government of Sir E. BIRKBECK's resolution urging the electrical connection of our coastguard and signal stations with lifeboat and rock-apparatus stations, and the appointment of a Royal Commission to investigate the further question of cable communication with lightships and rock lighthouses, it may be taken that the country is at last committed to something definite and practical. The Post Office, Sir JAMES FERGUSSON tells us, has the matter in hand, "showing that it has gone beyond the stage of contemplation;" estimates have been framed of the cost of telephonically connecting the coast-guard stations from the Isle of Wight to Lynmouth, and the work of framing estimates for communication all round the coast is being pushed on; meanwhile immediate steps are to be taken to run wires to the more exposed points.

ONE of the most satisfactory applications of the electrical transmission of power is the use of motors for hoisting. Cranes, travellers and lifts are intermittent in their action, and present few difficulties in driving. The use being intermittent, a motor can easily compete with a gas engine or small steam engine if a continuous supply of current can be drawn upon. A considerable number of travellers are now in use in machine shops. The construction of electrical cranes and capstans has met with great success, and several lifts are in constant use in this country, and succeed, in London, in competing with hydraulic supply. Unlike electric traction, there should be no difficulty in settling beforehand exactly what duty has to be performed by hoisting machinery. The travelling crane which is described in another column presents no very remarkable features, but gives a fair specimen of this kind of work. The complications of inertia and gradient do not present themselves in this problem, and this branch of electrical engineering is not hampered by any master patents.

THE specifications issued in connection with the electric lighting of the streets of Melbourne, which were printed in our issue of January 29, appear to have excited the sorrowful indignation of the great firm of Siemens and Halske. Asked by their Australasian agents to send in tenders they replied that they "could not consent to such a plan as the one proposed," and learnt with regret that it was intended to use "high-tension continuous current to run the arc and incandescent lamps in series." This system, the letter went on to say, was "based entirely on American principles, especially on constructions of the Thomson-Houston International Company;" the firm had given the matter their best consideration, and had decided that if they sent in tenders they would be defeated "on account of the prices of the inferior manufactures of the competitors." In conclusion Messrs. Siemens and Halske remarked that "it would be a pity if the Australian towns should subject themselves to American influence." Running incandescent lamps in series is certainly not in accordance with European practice, but running arcs in parallel would, we venture to think, be equally contrary to Australian notions.

A LINE drawn from Lowestoft to Littlehampton cuts off an important slice of this island, and that slice was at Easter time provided with a telegraphic service little better than was to be found by JULIUS CÆSAR when he landed thereon in B.C. 55. A few hundred thousand pounds would suffice to lay a network of trunk lines underground. Most of the Post Office lines run along the railways, and there would be no special difficulties in the way; but no amount of money would compel a Wheatstone instrument to work through such an underground network; and although the cost of repairing the damage done by the storm of 1886 and by the snow and gale of this Easter would go far towards the expense of a buried system, it would only be a stand-by in the event of breakdowns, and would not in any way replace the existing lines.

Personal.—Mr. Albion T. Snell has been appointed a member of Section III. (Dynamos and Motors) of the Crystal Palace Electrical Exhibition Jury.

Royal Victoria Hall.—Mr. Vernon Boys will lecture at the Royal Victoria Hall, Waterloo Bridge Road, on Tuesday, May 3rd, on "Flying Bullets."

Glasgow and West of Scotland Technical College.—Mr. Andrew Stewart has presented a handsome screw-cutting lathe to the electrical engineering laboratory connected with this College. The machine was made by Messrs. John Lang and Sons, lathe manufacturers, Johnstone.

The Engineering Exchange.—We are informed by the Secretary that the Engineering Exchange opens on Monday next, May 2nd, at 12 o'clock. The opening meeting will be in the Exchange Room of the Jerusalem (Limited), Billiter House, Billiter-street, E.C., where the committee have secured preliminary accommodation. All parties interested in engineering are invited to attend at the opening.

The Incandescent Lighting of the Chicago Exhibition.—According to the *Western Electrician* of April 16th, the Thom-

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son-Houston and Edison Companies have put in amended tenders for furnishing the incandescent lights required for the Chicago Exhibition, on the ground that they misunderstood the specifications. On April 9th a 50 per cent. reduction had been made by these Companies on the sums originally demanded (see *The Electrician*, April 22nd, p. 651). The demands of these Companies were, however, still considered too high by the Exhibition authorities.

Glasgow.—The electric fire-alarms made by Munro's Electrical Manufacturing Company, Glasgow, which the police authorities of that city were the first to adopt, and which are now so prominent over all the leading public thoroughfares of Glasgow, have just been ordered to be supplied to the city of Londonderry. It is said that the Liverpool municipal authorities are considering a proposal for their adoption.—Prof. A. B. W. Kennedy paid a visit to Glasgow last week, in connection with the central station which is being rapidly run up.

Johannesburg.—The Johannesburg Electric Lighting Company is now actively running additional wires, and over a thousand lamps are about to be added to those at present in use. Several houses, hotels, shops, &c., are being wired and fitted up by Mr. R. Lewis Cousens, the South African manager of Messrs. Woodhouse and Rawson. The same firm is also importing electric rock drills. The Thomson-Houston International Electric Company is also actively pushing its mining wares, Mr. Chas. Cohen, the agent of the Company, offering to lay down electrical plant for tramming quartz and other material, and to guarantee a minimum saving of 25 per cent. on the present method of animal traction.

Portsmouth.—Mr. Arnold Taylor, one of the Local Government Board Inspectors, held an inquiry on Wednesday last week in connection with the application of the Town Council to borrow £60,000 for the carrying out of Prof. Garnett's electric lighting scheme. Prof. Garnett, who explained the scheme, said Portsmouth was in a somewhat unique position on account of the extent of the area which came under the provisions of the Order, for in any case they were obliged to lay mains at least a mile from the central station to cover the area. The system he proposed to adopt was known as the high-pressure alternate-current system, with primary mains at 2,000 volts pressure, in connection with street transformers and a low-pressure secondary network.

Jardine Automatic Time Check.—An automatic electric time check has been devised by Mr. C. K. Jardine, of Demara. It consists of a box containing a drawer divided into two compartments, into which the workmen's numbered checks fall through a slot. When the hour for starting work comes round, the hands of a clock, making suitable contact, actuate an electro-magnet, which pulls an armature. This armature holds up a lever by means of a catch, and displays a card bearing the word "early" before a little window. When, however, the armature is attracted, the lever is released, and the word "late" is brought into view. The same mechanism also causes the checks to fall either into the "early" or "late" compartments. The apparatus is set by pulling out the drawer to withdraw the checks.

The "Guarantee" Cable Tariff to Australia. — The "Guarantee" arrangement made between certain of the Australian Governments and the Eastern Extension and other Telegraph Administrations for testing the effect of a 4s. rate to Australia has now been in operation for eleven months, with the result that the number of words transmitted has increased 48 per cent. over the corresponding period of 1890 and 60 per cent. over that of 1889, the year taken as the basis of the "Guarantee," while the revenue has diminished at the rate of £55,000 per annum. One-half of this loss is borne by the guaranteeing Colonies, and the other half by the Associated Companies, and the Indo-European Department of Her Majesty's Indian Government, according to their respective interests in the Australasian traffic. As the experiment, as far as it has gone, is considered not unsatisfactory, it has been decided to continue it for another year.

The Brussels Municipal Electric Lighting Contract.—The Brussels Municipality, as our readers are already aware, has been considering the electric light question for some years, and tenders have several times been invited. Finally, in October last, specifications were again duly drawn up and tenders once more invited. The following companies responded:—The Compagnie Internationale d'Electricité (Liége), the Allgemeine Elektricitäts Gesellschaft (Berlin), Schuckert (Nuremberg), Ferranti (Limited), Crompton and Co. (Limited), and the India Rubber, Gutta-Percha and Telegraph Works Company, of Silvertown. The Electricity Committee, after having considered the report of the three experts who examined the tenders, came to the conclusion that the financial condition of Brussels did not warrant the outlay necessary for the construction of a 10,000-light station, and a fresh tender for a 5,000-light plant was asked for from the India Rubber Company, and it is this last tender which the Committee are about to recommend the Conseil Communal to accept.

Electric Lighting in Time of War.—In a letter to *L'Industrie Electrique*, M. Marius Poirier relates some interesting experiences which he recently had in Chili. M. Poirier was sent out to Chili in charge of an electric lighting and transmission plant for the Santiago Exhibition. Just as the Exhibition was about to close the civil war broke out, and one Sunday morning M. Poirier received a telegram from the Minister of the Interior at Valparaiso, ordering him to betake himself immediately to that city. On arriving at Valparaiso M. Poirier was told to instal without delay a projector at Fort Boreas, commanding the Bay of Valparaiso. After an hour's search in the arsenal a Siemens projector was unearthed; a 12 H.P. threshing engine was then borrowed, and a Ganz Δ^3 dynamo was brought up from the Exhibition at Santiago (140 miles distant) by special train, together with a supply of posts and wires, and thirty-two hours after the receipt of the telegram the plant was at work, and ran well for six months until the projector was blown to pieces by a shell.

City and Guilds of London Institute. — The annual meeting of the governors and friends interested in the Institute was held at Mercers' Hall, Cheapside, on Wednesday; Lord Selborne presiding. The report showed that the income for the past year had amounted to £30,940, made up as follows:—Subscriptions and donations, £22,715; school fees and sundry amounts received from students, £8,225. The total expenditure had been £30,226. The amount voted by the council for the Central Institution at the beginning of the year was £12,000, and the expenditure £11,489; the students' fees amounted to £4,086, and the net cost of the Institution, after deducting the students' fees, &c. was £7,403. The amount voted by the council for the maintenance of the Finsbury Technical College was £8,794, and the expenditure there had been £8,786. The students' fees amounted to £3,032, and the net cost of the College, after deducting students' fees, &c., was £5,754. The expected income available for general purposes for the present year amounted to £31,870.

Electrical Measuring Instruments.—At a meeting of the Institution of Civil Engineers on Tuesday last, Mr. James Swinburne read a Paper on this subject. The Paper consisted mainly of a critical description of instruments. All volt-meters and ampere-meters, said the author, should be direct reading; milled heads and co-efficients were not admissible in modern electric light instruments. Volt-meters should absorb as little power as possible, as every watt taken was equal to the interest on £1. Horizontal dials and suspension fibres or compass points were to be avoided. Permanent magnets fell into undeserved disrepute a few years ago; but it was now more generally realised that they could be safely employed in instruments of the highest class. The meter was a most important instrument, as the whole profit or loss of a station depended on its accuracy. The chief faults in commercial meters, besides inaccuracy, were:—(1) Not starting until a large load was on; (2), absorbing power in shunt circuits; (3), absorbing power in the main circuit and reducing the light of the lamps; (4), getting out of order through the use of mercury; (5), needing frequent winding up; (6), wearing out through rapid movement of working parts; (7), stopping on account of insects or damp; (8), costliness.

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The Proposed San Francisco-Honolulu Cable.—The Government steamer Thetis, says the *Western Electrician*, is about to sail from San Francisco for Honolulu to complete the survey for the proposed submarine cable to the Hawaiian Islands. The Albatross commenced the work, and went so far as to make soundings over and back, when it was decided that she would be more valuable in Behring Sea, and the instruments and apparatus for sounding were transferred to the Thetis—a proceeding that delayed the work considerably, for the Thetis is not a vessel so well fitted for this class of service as the Albatross. The Thetis will follow the same general direction, filling in where it seems to be needed to ascertain more definitely the nature of the bottom of the Pacific. In the final plotting of the survey the lines laid down by the Albatross and the Thetis will be considered in conjunction with the much earlier one laid down by the Tuscarora. The Thetis will start from Point Conception and finish its survey at the Hawaiian end at Hilo. The Thetis is expected to complete its work in about six weeks, and then the Hydrographic Office will begin its charts, which will serve as a basis for the recommendation of the Navy Department for the line which may one day connect the American continent with the islands in the Pacific.

Another Transformer Patent.—American electrical engineers, says *Industries*, are somewhat uneasy at the issue of a patent to Deprez and Carpentier for transformer distribution, or rather transmission. It may be remembered that in the Gaulard and Gibbs case an old abandoned specification by Deprez and Carpentier was put in as an anticipation. Under a delightful system of patent law these dreamers, who never did any real work in transformer distribution, may pose as the inventors, provided they apply within two years of the date of actual use of transformers in America. If we are not mistaken, they have a monopoly of seventeen years, not beginning when they originally dreamed or even when they filed their American patent, but beginning now some fourteen years after the date of their European patents. Apparently an inventor should not apply at once for an American patent. He should apply, say, in Belgium, where there is no examination, and fees are low. He should then wait, and if, say, twenty years later, industry in the United States takes such a turn that his invention, or something like it, comes into use, he should wait eighteen months or so more, and then file an application. This is "hung up" by the Patent Office for, say, ten years, and he finally has seventeen years' monopoly after that, so that the whole trade is in his hands. The Americans thus really give Deprez and Carpentier a thirty years' monopoly—for that is what it really comes to if the patent be held to be good.

The New Telephone Company.—We have received copies of the papers now being issued by the New Telephone Company for the purposes of the canvass which they are undertaking in London. The New Telephone Company offer their London subscribers trunk line communication with Manchester, Liverpool, Glasgow, and all the important towns in Great Britain. Subscribers in the most distant towns, it is said, will be able to talk with each other from their own offices and private residences, the instruments fitted serving both for local and trunk communications. As it is the intention of the Company to adopt universally the twin-wire system, and to put that system, as far as possible, underground, it is considered necessary to name a somewhat higher tariff than was originally suggested. The rate provisionally fixed is an inclusive annual rental of £14, but the first 5,000 connections for which agreements are signed will be accepted at £12. 12s. per annum, on agreements for one, two or three years at the option of the subscribers. No charge whatever will be made to those subscribers who may be first joined up until 3,000 instruments are actually in connection through the exchange. These rates are, however, only applicable to lines not exceeding one mile in length from the nearest exchange; longer lines will be charged proportionally to their length at the rate of half the initial charge per mile. The Metropolitan area will, however, be so laid out that lines exceeding one mile in length will be very exceptional. Copies of testimonials from leading subscribers to the Company's Manchester Exchange, and extracts from the recent speeches delivered in the House of Commons by the Postmaster-General and the Chancellor of the Exchequer, are also being sent out.

Obituary.—We much regret to announce the death from pneumonia, following influenza, of Mr. Charles Hortsek, M.Inst.E.E., which took place on the 21st inst., after only a week's illness. Mr. Hortsek was a native of Hungary, and was at one time in the service of Messrs. Ganz and Co., of Buda Pesth, but had been many years in England and the Colonies. At the end of 1881, as soon as Mr. E. H. Johnson had determined on the nature of the Edison exhibit at the Crystal Palace Exhibition, Mr. Hortsek was placed in charge of the wiring, and continued in charge till it was completed. Many will remember the extraordinary effect produced by what was felt to be the great feature of that successful Exhibition, the huge floral electrolier, provided by Messrs. Verity, the switching in and out of which—now so simple and unmasked—carried away the audience night after night. We are apt to forget the novelty of that Exhibition, but those who visited the Crystal Palace frequently will know that even to-day no one can carry out wiring in a more perfect manner than was effected by Mr. Hortsek. He afterwards went to the Cape of Good Hope and wired the Houses of Parliament, under the auspices of Mr. W. H. Preece; these were the first Houses of Parliament lighted by electricity. He was then sent to India, by Edison's Indian and Colonial Electric Company, to introduce incandescent lighting there. Arrangements had been made with the head of Government telegraphs to make a complete experimental installation of 100 lamps, on which work Mr. Hortsek was engaged when he became very ill. The doctors said that his life depended on his leaving India as soon as possible, and he had no choice but to abandon the work and return to England. He was during the last two years in the service of the Westminster Electric Supply Corporation, and was in charge of their system of conductors and street mains. He was a most zealous and indefatigable worker, and of great natural ability, and was highly esteemed and respected by all who enjoyed his acquaintance.

Governing Water Wheels in Electric Railway Service.—The Ottawa Electric Railway Company, says the *Western Electrician*, operates a line consisting of eight miles of double and four miles of single track. The system was constructed in seven weeks, and cars were put into service in the latter part of June last year. The equipment consists of 16 cars of the vestibuled type, and the Westinghouse system is employed, single-reduction 20 H P. motors being used. Power is obtained from the famous Chaudière Falls, two turbines driving two 100 H.P. Westinghouse compound dynamos, a third machine being kept in reserve. At first the turbines raced seriously when the load was thrown off. Now, however, the water-wheel gates are raised and lowered instantly by a mechanical arrangement, and a resistance load is kept on the dynamos. The mechanical device consists of a right and left hand lever which operates a shifting belt, which in turn operates a gear wheel on each of the water-wheel gates, so as to rapidly lift or lower them. This contrivance solved the problem for ordinary fluctuations, but not when only a few cars were in service. To overcome this difficulty an electrical regulator was resorted to. A large tank was constructed, and into it a stream of water is kept constantly running. Five coils of iron wire, in shunt with the trolley wire, are placed in the tank and connected to a grouping switch. The amount of current diverted through the coils is, for the five movements of the switch respectively, 25, 50, 75, 100, and 125 amperes. The energy consumed, then, with the lever on the last notch at 500 volts is equal to about 84 H.P. The man on duty watching the voltmeter has the belt-shifting water gate controlling lever on his right, and the current diverting switch on his left. The electrical device is only used occasionally, early in the morning and late at night. The voltmeter is connected with the centre of distribution, a mile distant, so that regulation for the centre of distribution is secured without regard to drop in the feeders. There would be an objection to the employment of an automatic device in combination with the electrical arrangement, in that practically a constant load would be maintained on the dynamos. The apparatus was designed by Mr. T. Ahearn, of the Chaudière Electric Light and Power Company of Ottawa.

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TRANSFORMER PREDETERMINATIONS.*

BY DR. J. A. FLEMING, M.A.

(Concluded from page 655.)

We shall now point out another means by which the magnetising current can be approximately predetermined if the total loss in the core is known.

If hysteresis and eddy current energy loss were entirely absent from the core, it is clear that the whole energy conveyed to the primary circuit of a transformer on open secondary must be simply dissipated in heating the copper of the primary circuit; and hence, if this copper loss is also small the actual power given to the transformer would be zero. Under these circumstances the phase of the primary currents would be very nearly 90° behind that of the impressed electromotive force. If an iron core so well laminated that eddy current is practically absent is employed, then it will still be the case that the instant of the maximum value of the periodic primary current will be coincident with the instant of zero primary electromotive force, even though the form of the primary current curve may be very different from that of a simple sine curve. This is true even though the magnetisation of the core is carried up very much above the "knee" of the magnetisation curve.

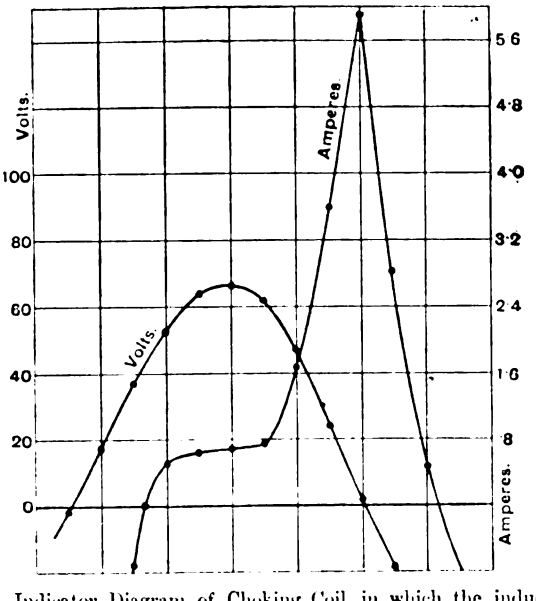

FIG. 1.—Indicator Diagram of Choking Coil, in which the induction is carried up to about 17,000 or 18,000 C.-G.-S. units.

In Fig. 1 is shown the indicator diagram of a small choking coil, or transformer with no secondary circuit. The core was composed of fine iron wire, No. 36 gauge in diameter, wound up into a ring. The ring was wound over with insulated wire, and the choking coil† so formed had an indicator diagram taken by Ryan's method. The dimensions and data were as follows:—

Mean diameter of ring core	8·9 cm.
Area of cross section of core	3·14 sq. cm.
Mean length of magnetic circuit	26·5 cm.
Maximum induction density in core...	17,800 C.-G.-S.
Number of turns of wire.....	200
Resistance.....	Negligible.
Frequency	92
Impressed E.M.F. maximum value ...	65 volts.
Mean loss in the core	·33 watt per c.c.

In this fine wire core eddy current loss is practically absent at this frequency, and from the diagram it is seen that although the current curve is very far indeed from being a sine curve, yet its maximum value, of 5·9 amperes, happens at the instant of zero electromotive force. Another such diagram for a similar core is shown in Fig. 2. In this case the induction density is not carried up so high, but the same fact may be noted, viz., that the maximum value of the current happens at the instant of zero electromotive force. If we next consider the action of the eddy currents, we shall find that their presence in the core always causes the phase of the primary current to be advanced or brought back more into consonance with that of the impressed electromotive force.

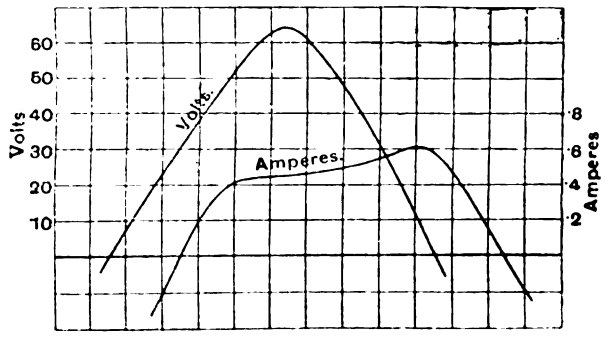

FIG. 2.

The diagram in Fig. 3 is the indicator diagram of a choking coil composed of a solid cast-iron core wound over with 200 turns of wire of negligible resistance. The ring had a mean diameter of 8·6 centimetres, and a cross sectional area of 2·7 square centimetres. An alternating electromotive force having a frequency of 195 was applied to the circuit, and the diagram of current taken by Prof. Ryan. In this case the eddy current loss is very marked. From the observed value of the induction density **B** and the primary current (i), a diagram of core losses was formed (*see* Fig. 4), the outer curve being the (**B**, i) curve, and the inner curve the curve of static hysteresis deduced from separate observations. In the diagram in Fig. 4 the vertical divisions each represent 0 0038 of a gauss, and the horizontal ones each represent 4 amperes.

The whole area of the outer curve reckoned in gauss-amperes or joules is nearly 0 8 joule, and this is, therefore, the whole energy wasted in the core in one complete magnetic cycle. Since the frequency is nearly 200 the whole loss of power in the core is nearly 160 watts. From the dimensions of the ring we find easily that the total volume of the iron is 73 cubic centimetres. The diameter of the cross section of the ring is $\sqrt{3·44}$ centimetres. The maximum value of the impressed electromotive force was 26 volts, and that of the induction density 4,930 C.-G.-S. units. The frequency was 195.

The magnetic permeability of cast iron corresponding to an induction of 5,000 C.-G.-S. is nearly 200. If we attempt to calculate the current through the circuit when a periodic electromotive force, having a maximum of 26 volts, is applied to the coil, we shall find that we get a value far below the

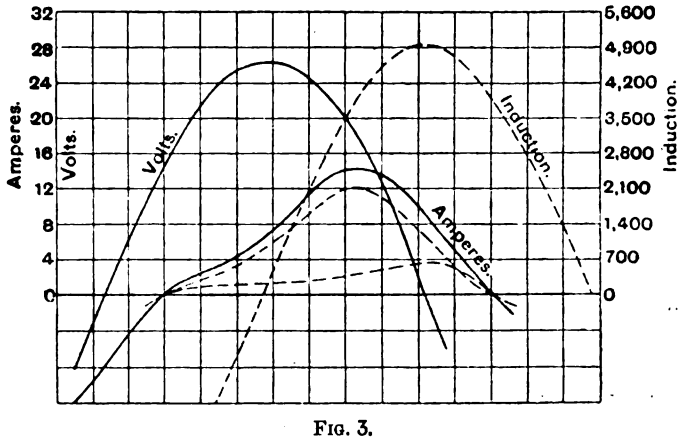

FIG. 3.

observed value. For if we insert in formula (7) the proper values, viz., $E = 26$, $l = 27$, $n = 195$, $S = 2·7$, $N = 200$, and $\mu = 200$, we get

$$I = \frac{10^9 \times 27 \times 26}{8 \times 9·87 \times 2·7 \times 200 \times (200)^2 \times 195} = 2 \text{ amperes},$$

whereas the observed maximum value of the current is about

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† One of the coils employed in some experiments by Messrs. Fortenbaugh and Sawyer.

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14 amperes. This is because the immense eddy current loss renders the choking coil virtually a transformer with a closed secondary circuit.

We shall now proceed to point out an empirical rule which will in nearly all cases enable the total core loss to be predicted when the so-called "magnetising current" is given, and *vice versâ*, provided that the iron circuit is a closed circuit, and that the iron is fairly well laminated. Under these circumstances the total loss in the core can be calculated from the core dimensions and from the secondary electromotive force. If the reader will refer back to *The Electrician*, January 22, p. 296, in which is shown the harmonic analysis of the primary current of a transformer on open secondary, he will see that the current curve can be analysed into a principal sine curve which lags one-eighth part of a phase behind the impressed electromotive force, and also into two smaller components. The principal sine curve has a maximum value a little less than that of the actual current curve. The mean power given to the transformer during one period is obtained by taking the mean of the values of the equally-spaced instantaneous currents and corresponding electromotive forces. It is quite evident that

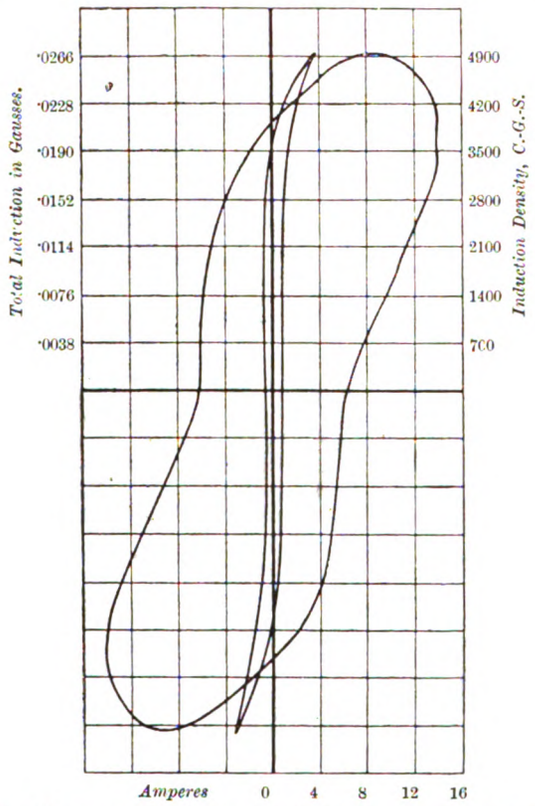

FIG. 4.—Diagram of Static Hysteresis (*Inner Curve*) and Total Loss (*Outer Curve*) for a Cast-Iron Ring. (Number of turns of wire in ring, 200; section of ring, 2·7 sq. cm.)

it is possible to so place a true sine curve of current with reference to the electromotive force curve that the mean power represented by this equivalent sine current is the same as that due to the actual current. It is also evident that a simple sine curve having the same maximum ordinate as the real current curve, but placed one-eighth part of a complete period in phase behind the impressed electromotive force curve, would, if it represented a current, be equivalent in mean power to the actual current. Let E be the maximum value of the electromotive force, and let it vary in a simple, periodic manner. Then $\frac{E}{\sqrt{2}}$ is the $\sqrt{\text{mean}^2}$ value of this electromotive force. It is the value which would be read on a Cardew voltmeter or a dynamometer. In the same way if I is the maximum value of the equivalent simple periodic current of equal power value with the real current, $\frac{I}{\sqrt{2}}$ is its $\sqrt{\text{mean}^2}$ value. If θ is the angle of phase difference between E and I, and W is the true value of the power given by the currents I, we have

$$\frac{E}{\sqrt{2}} \frac{I}{\sqrt{2}} \cos\theta = W.$$

It is convenient to call W the *real watts*, and the simple product of the $\sqrt{\text{mean}^2}$ values of E and I, viz.: the product $\frac{E}{\sqrt{2}} \cdot \frac{I}{\sqrt{2}}$ the *apparent watts*. The cosine of the angle of lag in this case is the ratio of real to apparent watts.* The apparent watts are the simple product of the volts as measured by a hot wire or Cardew voltmeter, and the current as measured by a Siemens dynamometer. In nearly all cases of closed iron circuit transformers with fairly well-laminated cores it will be found that the ratio of the real watts, or true mean power taken up in the core when the transformer is on open secondary circuit to the apparent watts, or product of the primary working volts and the magnetising current as read on the usual instruments, will be a number not far removed from 0·75, or somewhere between 0·7 and 0·8; that is to say, near to $\frac{I}{\sqrt{2}}$. This number is the cosine of 45°, and the rule in effect comes to this:—The real power taken up in the core is that which would be given to the transformer, if we suppose the magnetising current to be a simple sine curve current, and to lag about 45° behind the impressed electromotive force. In order to show that this is so, we shall compare the actual power taken up in the core (which includes, of course, any small loss in the primary circuit) of transformers on open secondary circuit with the product of the $\sqrt{\text{mean}^2}$ values of the primary electromotive force and the magnetising current, and show that the ratio is in all cases not far from $\frac{1}{\sqrt{2}} = 0{\cdot}707$.

Transformer tested.	Primary volts. $\sqrt{\text{mean}^2}$ value = E.	Primary (magnetising) current. $\sqrt{\text{mean}^2}$ value = I.	*Real watts*, or true mean power taken up in the transformer (core) on open secondary circuit = W.	*Apparent watts*, or product of E & I, = W^1.	Ratio $\frac{W}{W^1} = P$. = *power factor.*
Westinghouse 1 H.P.	1,000	0·14	95·7	140	0·68
Mordey ..... 8 H.P.	2,400	0·07	126	174	0·72
Stanley ..... 2 H.P.	1,000	0·053	37·5	53	0·707
Westinghouse 2 H.P.	1,000	0·061	48	61	0·79
Slattery ..... 2½ H.P.	1,000	0·056	45·5	56	0·81
National ..... 2½ H.P.	1,000	0·112	75·0	112	0·67

The results from many other closed magnetic circuit transformers tested are in the same direction, and show that for most ordinary types of well-laminated closed iron cores the relation between primary volts, magnetising current, and total loss in the transformer on open secondary circuit is expressible by the empirical formula

$$\textit{Primary volts} \times \textit{magnetising current} \times P = \left\{ \begin{matrix} \textit{Total loss in watts} \\ \textit{in transformer.} \end{matrix} \right.$$

The volts and current values being the $\sqrt{\text{mean}^2}$ values or the dynamometer values; and the constant P having a value varying from about 0·7 to 0·8. It is convenient to call P the *power factor* of the current.

The power factor for a closed magnetic circuit transformer on open secondary is never far from 0·75. Hence we have a simple practical rule, viz., the real power lost in the transformer so worked is three-quarters of the apparent watts supplied to it.

* When a current curve is a true sine curve, its *lag* with respect to another true sine curve representing electromotive force or current has a definite meaning. If it is not a true sine curve then the *lag* of its maximum value and of its zero value is not the same thing.

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In cases where the eddy current loss is very large, as in the case of the cast-iron ring above mentioned, the *power factor* in the above formula is much more nearly unity than 0·7. Thus, for the cast-iron ring (Fig. 3, *ante*), the $\sqrt{\text{mean}^2}$ value of the current is 8·6 amperes, maximum value being 14 amperes. The $\sqrt{\text{mean}^2}$ value of the primary electromotive force is 18·5 volts, and $18{\cdot}5 \times 8{\cdot}6 = 159$. The apparent watts are therefore 159, whilst the real watts taken up were found to be 160. On the other hand, for open circuit transformers, when on open secondary circuit, the *power factor* is found to be much less than 0·7, often as low as 0·1.

In connection with this point it may be useful to point out that the total eddy current and hysteresis losses in well-laminated soft-iron cores can be predetermined with sufficient accuracy for most purposes by very simple formulæ. Prof. J. J. Thomson has given (see *The Electrician*, April 8th, p. 599) a complete investigation of the behaviour of iron rods or plates under alternating magnetising force. The formulæ given for the eddy current and hysteresis losses involve some handling of hyperbolic trigonometry in applying them to practical work. For any cases likely to occur in practice, viz, when the rods or plates of iron are less than 1 millimetre in diameter it can be shown* that if X is the thickness of the plate in mils (1 mil = ·001 in.), n is the frequency and B the maximum mean value of the induction, then the loss in watts per cubic centimetre W in that iron under such alternating force is given by the expression

$$W = \left(\frac{X\,n\,B}{10^8}\right)^2 + \cdot 002\,n\,B^{1\cdot 6} \quad . \quad . \quad . \quad . \quad (1)$$

where the first term expresses the eddy current loss, and the second the hysteresis loss. Compare, for instance, the results of this simple formula with the results derived from the application of the complete investigation of Prof. Thomson, as given by Prof. Ewing (in *The Electrician* of April 15th, p. 634) for maximum inductions of 4,000, 6,000, 8,000, and wrought-iron plates ½ mm. and ¼ mm. thick. The formula above (1) gives the predetermined losses as follows, for a frequency of 100 :—

Plates ¼mm. thick.

Losses in watts per cubic centimetre.

B.	Eddy.	Hysteresis.	Total.	(True.)
4,000	0·016	·012	0·136	·012
6,000	0·036	·022	0·256	·028
8,000	0·064	·035	0·414	·044
	Plates ½mm. thick.			
4,000	0·064	·012	0·184	·018
6,000	0·144	·022	0·364	·039
8,000	0·256	·035	0·606	·064

The results in the last column marked (True) are those calculated by Prof. Ewing from Prof. Thomson's formulæ. For plates 1mm. thick and B = 4,000, the approximate formula gives the total loss equal to 0·0376 watt per cub. cm., and the true formula gives it 0·0379. Hence, for practical calculations and predeterminations, the above very handy rule can often take the place of the more difficult one in predetermining core losses in transformers.

WHY SOME PACKING DOES NOT PACK.†

BY ROBERT GRIMSHAW.

In order to make an engine that will pack well, there must be considerable depth of stuffing-box, and the gland must not be so deep, proportionately, as to fill it up and make it impossible to put more than about two coils of packing into it. Not one engine in three on the market has a deep enough stuffing-box and proportionately short enough gland. The Straight-Line Engine Company get along for quite a while without any packing at all, because they have about four rod diameters in length in their box, and that is bushed with Babbitt metal, leaving an annular orifice of very slight thickness so long that the steam cannot find its way out before the back-stroke is completed and the pressure removed.

For the same reasons that call for deeper stuffing-boxes most of those that we see are of too slight diameter, leaving no chance to get in rings of sufficient size. With from 50 to 100 per cent. greater space between rod and stuffing-box wall, rings could be used which, by gentle pressure, would be perfectly elastic and would make steam-tight joints without absorbing undue power in friction, and without undue wear of packing and rod.

A further error made by some engine-builders is the use of glands that are driven in by two bolts, one each side of the rod. Of course this is a lighter and cheaper construction than the screw principle, but at the same time it often results in the gland being cocked and the rod worn too much on the sides, while there may be blowing on the other two quarters of the rod's circumference. Any engineer can stop almost any engine with this type of gland, by merely tightening up on one of the bolts. In fact, he can without much trouble do the same thing with many of the screw type, too—which should give him a lesson on the difference between packing and jamming.

After getting the packing in, whether it is cut right or not, and whether or not it has grit on it, there is a chance of injustice being done to it and its maker by its being set up too hard. For every case where a box is too loosely packed there are about three that are set up too hard, with the three-fold bad effect of consuming power, scoring the rod, and wearing out the packing too fast. Reference to the remarks about jamming the valve-stem by cocking the gland or setting it up too hard is appropiate in this connection. Packing is often set in wrongly, care not being taken by the engineer to break joints, so that where it is cut badly there is a nearly straight steam-way through which leakage is very easy.

It will usually be found best for the engine tender to run the gland up hard at first, before the engine turns over, then slack it back until there is just a tiny leak of steam—a gentle puff, during the first day ; then the second day it may be set up a mere trifle, so as to leave only the faintest suspicion of a leak ; and if I had my way about it I should let this little leak show as long as the packing was run. What steam came out through so slight a crack would cost but little, and the wear of the rod and packing would be less, while the power consumed by friction would be more than enough to pay for the steam. Besides this there is some slight lubricating power in the steam and water.

* The proof of this is given in full in the forthcoming Second Volume of the "Alternate-Current Transformer," from which this article is taken.

† Abstract from the *India Rubber World* of New York.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-NIGHT) FRIDAY, April 29th.

INSTITUTION OF CIVIL ENGINEERS.

7.30 p.m. Students' Meeting. Paper to be read: "The Steam Hammer and its Relation to the Hydraulic Forging Press." By H. H. Vaughan, Stud. Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Physiology of Dreams." By Dr. B. W. Richardson, F.R.S.

MONDAY, May 2nd.

ROYAL INSTITUTION.

5 p.m. Annual Meeting.

SOCIETY OF ENGINEERS.

7.30 p.m. Ordinary Meeting. Paper to be read on "Dry Crushing Machinery." By S. H. Cox.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture, V., 1. "Recent Bacteriological and Chemical Research in Connection with the Fermentation Industries." By Percy F. Frankland, F.R.S.

TUESDAY, May 3rd.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed: "Electrical Measuring Instruments." By James Swinburne. At this Meeting the monthly ballot for members will be taken.

WEDNESDAY, May 4th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "The Bradford Corporation Electricity Supply." By James N. Shoolbred.

THURSDAY, May 5th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Chemistry of Gases." By Prof. Dewar, F.R.S.

INSTITUTION OF MECHANICAL ENGINEERS.

7.30 p.m. President's Address and Papers to be read.

FRIDAY, May 6th.

INSTITUTION OF MECHANICAL ENGINEERS.

7.30 p.m. Papers to be read.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Sensitiveness of the Eye to Light and Colour." By Capt. Abney, F.R.S.

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The Electrician.

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ELECTRIC TRACTION.

The comparatively slow progress of electric traction in this country seems to be due to the fact that in the construction and equipment of an ordinary tram line only a trifling amount of mechanical skill is needed. The car-builder in arranging a short wheel-base is limited only by the conditions of balance to avoid a tip up. The springs, drawbar, and brakes are generally of the simplest and most obvious construction, and ingenuity seems to have been expended chiefly in swivelling bodies, and in the really important matter of the design of wheels and rails. Electric traction on the other hand, if it is to be successful, calls for not only a thorough knowledge of the design and construction of motors and perhaps the management of accumulators, two subjects in which nine electric light engineers out of ten are by no means well versed; but a practical acquaintance with mechanism and mechanical science that not one electrical engineer in twenty can command. Besides this, a general knowledge of tramway engineering, such as it is, and of steam economy is requisite. In the infancy of electric traction, the problem to be solved was not understood, and the experimenters were, *à fortiori*, utterly in the dark as to the proper methods to be used. Owing to the more urgent demand in America, the problem received an American solution. That is, the cars *had* to go, somehow. The perseverance, ingenuity, and expenditure on experiments were on the colossal scale appropriate to that country. One difficulty after another was attacked and surmounted, dozens after dozens of motors and gears were thrown on the scrap heap, and so long as there are more lines to be

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equipped, we cannot expect American traction engineers to sit down and generalise, and state the problem which, in their own fashion, they have solved. We are likely, therefore, to be misled if we work backwards from a study of the means by which the end has been attained. Moreover, so many different systems are in use that a proper comparison of the essentials is very difficult, and the interesting experience which has been or is still being acquired in Leeds, is a warning that American electric traction is a collection of a number of details which have survived experimental work, and that under modified conditions further experiments will be needed.

A very slow, unexciting, and old-fashioned way of approaching the solution of such a problem as this is to quietly consider what it is that we want to do; or if we have, thanks to Mr. Reckenzaun, a careful account of what others have done, to give attention to such general principles as we may find in them. The electrical side of the work, if we dismiss the series system as being still too complicated and undeveloped, is very simple. The question of accumulators may be very concisely stated. It rests with one or two makers to give confidence in the endurance of the plates by a fair maintenance contract and a substantial guarantee. A considerable expenditure of ingenuity has been made upon the closed-conduit system; but the nuisance of a tramway in any form is not appreciably increased by a slot, if that be a mere extension of the groove of one of the rails. The design of a motor to deliver a given power at a given speed, or a given torque for a given current, is a mere drawing-office job. Switches for introducing resistance or altering the grouping of cells present no real difficulties, if they are wanted, while they offer a fine field for inventive ingenuity.

One of the first questions which the electrician asks is, "Why do you want two 15 H.P. motors to do the work of two horses?" It is no use asking the tramway engineer such a question, for he is not necessarily a skilled mechanical engineer. The railway engineer will not appreciate the difficulty, for he has only to notch down his links in order to start. Our American friends probably began, as most of us have done, with a three or four horse motor. This would not do; and by successive experiment it was found that a couple of 15-horse motors would not only drive the car comfortably, but in the event of the breakdown of one, the other would run the car home.

If the life of a tramcar motor could be insured, the armature would probably be calculated as being ten times more likely to burn out than that of a dynamo. The reason is simple. The starting pull is difficult to foresee, and if at a pinch a long pull and a strong pull is wanted, the armature has to stand the brunt of it in the shape of a heavy current. As the strength of a chain is the strength of its weakest link, so conversely, the size of a tram motor is fixed by the greatest effort that it is called upon to exert. Since it is current only that gives the torque required for starting, the accumulator system has some advantage, in allowing the connection of cells in various groups in parallel; and a similar benefit in a less degree is to be found in the use of more than one motor, or in the duplicate system which Mr. Holroyd Smith is using at Bradford. The use of the gearless motor in America is described elsewhere in the present issue; and Mr. Short argues that the low electrical efficiency which is inseparable from a slow-running motor is compensated by the absence of mechanical losses in gearing. As far as economy of power is concerned, it does not matter whether a direct driving motor is used with an efficiency of 60 or 65 per cent., or whether a high-speed armature with an efficiency of 80 per cent. be connected to gear with a similar efficiency. Mechanical instinct is wanted in this work, rather than electrical science. Ingenious comparisons have been made between the life, weight, cost, expense of maintenance and work of a horse and of an accumulator; and the same might be done for a motor. When some first-rate mechanical engineer can be found to give his mind to the matter, one who will not be too proud to place the electrical work in the hands of a thoroughly experienced motor builder, an English solution to the problem of electric traction will be forthcoming.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 609.*)

§ 77. **Correction for Finite Cross Sections.**—The ratio of the mean radius of the fixed coils to the mean radius of the suspended coil is the only quantity to be determined with the utmost accuracy in a properly designed current-weigher. The other measurements required are easily made with sufficient accuracy, since in a properly designed current-weigher, their errors only affect the result to a very small degree. We need not, therefore, give any description of Lord Rayleigh's actual measurements.

To calculate the force experienced by the suspended coil due to unit current through both the fixed and suspended coils, Lord Rayleigh made use of the formula given in §61, employing a set of tables which he had calculated by the aid of Legendre's "Tables of Elliptic Integrals." In this formula, however, no account is taken of the finite space occupied by the windings on the coils, so that a formula of correction becomes necessary. Such a formula is furnished by a theorem attributed to the late Mr. H. J. Purkiss (*see* Maxwell, *Electricity*, Second Edition, §706, Appendix II.). Let a_1 be the mean radius of the fixed coils, $2h_1$ the radial depth, $2k_1$ the axial width of the windings, supposed of rectangular section, n_1 the number of turns of wire, and let the suffix $_2$ refer to similar quantities belonging to the suspended coil; also let the attraction per unit current between two co-axal coils of radii a_1, a_2 whose planes are separated by a distance b be denoted by the symbol $f(a_1, a_2, b)$. For any given values of a_1, a_2, b, the value of $f(a_1, a_2, b)$ can be found by the aid of the formula of §61. Then as long as h, k are small, the total attraction between the coils is given by the formula

$$\frac{1}{6} n_1 n_2 \left\{ \begin{array}{l} f(a_1+h_1, a_2, b)+f(a_1-h_1, a_2, b)+f(a_1, a_2+h_2, b) \\ +f(a_1, a_2-h_2, b)+f(a_1, a_2, b+k_1)+f(a_1, a_2, b-k_1) \\ +f(a_1, a_2, b+k_2)+f(a_1, a_2, b-k_2)-2f(a_1, a_2, b) \end{array} \right\}$$

The proof of this formula does not present any difficulty to the student who can use Taylor's theorem intelligently, and is acquainted with the elements of the integral calculus. The proof of the theorem forms an excellent exercise. Lord Rayleigh computed each term separately by the aid of his table.

§ 78. **The Constant of the Instrument.**—In this way the force due to unit current experienced by the suspended coil was calculated in terms of the quantities which were observed. Knowing the force in terms of the current, Lord Rayleigh was able to reverse the process, and from the observation of the force by the current-weigher was able to deduce the value of the current. The force experienced by the coil is estimated by the weight which has to be put into the other pan of the current-weigher to preserve equilibrium. The weights used displace air, so that a small correction is necessary on this account. Remembering that the force is proportional to the square of the current we see that the relation between the current and the weights may be written

$$i = \mu \sqrt{m}$$

where m is the observed difference of weights in air necessary

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to counterpoise the suspended coil when the current is reversed in the fixed coils. From his measurement of the coils, Lord Rayleigh found $\mu = 0370484$.

The difference of weights is spoken of since the readings were always taken by reversal of the current in the fixed coils, for which purpose a suitable key was provided. The difference of the weights required to balance the suspended parts in the two cases gives twice the force of attraction between the suspended coil and the fixed coils, independently of the action upon the former of any other part of the circuit, and of terrestrial or other permanent magnetism. The current usually employed by Lord Rayleigh was about one-third ampere, and the double attraction was about the weight of one gramme.

§ 79. **Method of Measurement.**—We will now explain briefly the method followed by Lord Rayleigh in taking the measurements of the current. The arrangement of the apparatus is shown diagrammatically in Fig. 55. The current was supplied by about 10 either Grove or secondary cells A, and traverses a resistance B, which can be adjusted so as to bring the current to the desired value. It then passes two or more silver voltameters arranged in series C, a rough tangent galvanometer D (convenient for a preliminary test of the strength and direction of the current). It flows round the two fixed coils F of the current-weigher in opposite directions, and finally passes through the suspended coil G, being led to and

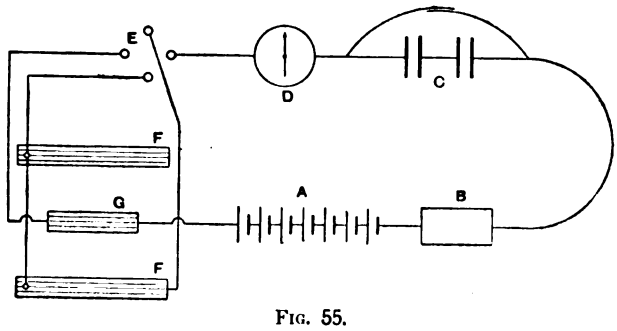

Fig. 55.

from the coil by a number of very thin flexible copper wires arranged "in parallel." At E is a commutator, by means of which the current can be reversed in the *fixed* coils. A shunt of suitable resistance was provided, so that during the preliminary adjustments the current could be diverted from the silver voltameters. The electromotive force of the storage cells (when in good order) remained almost constant during an experiment; but the gradual warming of the copper conductors caused a falling off of current, but by allowing the current to flow by the shunt for about half an hour before the beginning of the actual experiment, the temperature of the copper conductors became very nearly steady, so that in the experiment itself only a small falling off of current was found.

The direction of the current in the fixed coils of the current-weigher was reversed every few minutes by means of the commutator E, and the difference of weights on the pan of the balance required for equilibrium was noted. The weights necessary for balance (in the same position of the key) altered somewhat, both on account of the variation of the current and also from the formation of air currents due to a slight progressive warming of the suspended coil. By recording the times of each weighing two curves were plotted, from which could be ascertained what would have been at any moment the weighing in either position of the key. The difference of the ordinates gives what would have been observed if it had been possible to make both measurements simultaneously. As mentioned above, the difference of weights was about 1 gramme. The weighings were recorded to milligrammes only; but the accuracy really obtained was greater than might appear, since by anticipating somewhat the change in progress it was possible to note the *time* at which the balance demanded an integral number of milligrammes. The whole duration of an experiment was from three-quarters of an hour to two hours, measured by a chronometer; and as a weighing could be made about every five minutes there was ample material for the construction of the curves. For comparison with the deposited silver the *mean* value of the current is required, while what would be obtained directly from the curves would be the *square* of the current. The whole interval was divided into periods (usually of fifteen minutes), and the difference of ordinates corresponding to the middle of the periods was taken from the curves. The mean of the square roots of the numbers thus obtained gives a result to which the rate of silver deposit should be proportional.

Lord Rayleigh's numbers show that this relation is fulfilled with great exactness, and his work affords a very valuable confirmation of the law of electrolysis, according to which the amount of chemical decomposition is proportional to the quantity of electricity, measured electro-magnetically, which passes round the circuit. In fact, the value of $\sqrt{m}/$ (deposit per second) (*see* § 78), which according to this law should be absolutely constant, lay between the narrow limits 2413·7 and 2415 5. These numbers are derived from a table in which Lord Rayleigh included all the experiments he made, in which the manipulations were successfully conducted, and from which no experiment was excluded except in consequence of a decision made *before the result was known.*

§ 80. **Some Special Points.**—In connection with the method of taking measurements, there are a few more points worthy of mention.

It is necessary that the suspended coil should in every case be brought to rest in its proper position, corresponding to the zero of the pointer of the balance. Lord Rayleigh found it desirable to give the balance a shorter period of vibration than usual. To obtain control over the arc of vibration an auxiliary coil was introduced, through which, by the aid of a key, the current from a Leclanché cell could be made to pass. By this means a force tending to raise or lower the suspended parts could be brought into play at will; with a little practice it was possible to stop the vibrations with very little delay.

The current was led into the suspended coil by means of fine flexible copper wires. To diminish the force conveyed by these to the suspended coil, they were bent so as to place themselves naturally in the required positions before the final solderings were made. "It is important, however, to observe that no assumption is made as to the equality of these forces before and after the passage of the current. Under its influence the fine wires are, no doubt, sensibly warmed, but this effect and any consequent alterations in the mechanical properties are the same in both sets of readings, the *only* change relating to the direction of the current in the fixed coils." The reason for using a number of fine wires instead of a single thicker one is that it is much easier to bend several wires placed side by side than to bend a single wire of cross section equal to the sum of the cross sections of the separate wires. In fact, if there are n wires in the bundle, the effort of bending the single thick wire would be n^3 times that required for the bundle.

"In the absolute measurements the determination of the interval (never less than three-quarters of an hour) between the first passage of the current through the voltameters and its final cessation could readily be affected with sufficient accuracy (probably to 1/10,000), but a slight correction is called for in order to take account of the loss of time incurred at each operation of the reversing key, which controlled the direction of the current in the fixed coils (§ 79). To obtain the necessary data for this correction the main current was led through a few turns of wire surrounding a mirror galvanometer. The resulting deflection is independent of the position of the key, but at the moment of reversal the current is interrupted, and the spot of light falls back towards zero. From a comparison of the amount of this falling back with the steady deflection, in conjunction with observations of the period of vibration, it is easy to deduce the time of interruption. It proved to be less than one-tenth second, and was so nearly constant that after sufficient experience had been gained, further observations were judged to be unnecessary." The connexions for this purpose are accordingly not shown in the diagram.

(To be continued.)

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NOTE ON ELECTRIC PERCUSSION DRILLS.

BY ALBION T. SNELL.

Although there has been much talk about the advantages of electric percussion drills, experience certainly seems to show that the workshop tests are not realised in practice. Many inventors have entered the field, and ingenious methods have been devised for effecting the reciprocating motion without opening the circuit; but yet drill after drill has failed to do continuous work on "headings" under the conditions of ordinary mining, although each has probably performed satisfactorily in the workshop and exhibition. The reason is not far to seek. Driving stone drifts is about as rough work as can be imagined, and the men employed are as rough as the work. So the drill must stand usage so severe that it can only be gauged by actual experience. The writer has seen an Ingersoll air-drill lying under a heap of stone that had fallen on it when the *débris* was being cleared after blasting, and which had been left in this state when the shift finished. But more important than even the rough treatment is the question of ventilation. Obviously, when driving a "heading" there is a tendency for the air to stagnate, and therefore difficulty in removing the powder fumes after the shots are fired, unless fresh air be brought continuously up to the "face." The compressed air drill exactly meets this difficulty; the exhaust from the drill causes a steady draught which cools and purifies the air; and the powder fumes can always be cleared by turning on a little air. The electric drill, on the contrary, under such conditions, tends to increase this difficulty, for the rapid reversals of magnetism soon heat the body of the drill sufficiently to materially increase the temperature of the "heading" if it be confined or the ventilation sluggish.

This disadvantage is probably sufficient in many cases to make electric drills impracticable, the mere question of cost of "boring" (gauged by working in well-ventilated spots) being altogether subordinated to other considerations. Of course, for a variety of purposes, such as quarrying, working in ventilated levels, &c., these objections have no weight. But even under these conditions the electric percussion drill has not attained much success. The reason appears to lie in the drill itself. In the first place, reciprocating magnetic devices are not efficient; indeed, solenoidal action is the least effective manner of converting electric energy; its proper function seems to be attraction through a very short range. In the early days of electric motors, designers tried to imitate the reciprocating action of the steam-engine, with results which are a matter of history. It was not till a rotary motion was insisted on that the motor became an efficient machine. *En passant*, the converse seems to hold good with the steam-engine. It is perhaps worthy of remark, too, that the most general and successful application of magnetic reciprocating action is found in the ordinary electric bell. Drills have been designed to work on somewhat similar lines (see Fig. 1). A and A_1 are two coils, so connected to the terminals *a* and *c* that the lever L will put them severally into circuit as it rests on one or the other. An iron core or plunger is attached to a shaft carrying a tappet, which works the lever *l*. This is a strong though primitive device, which would be useful in all mines having a lighting circuit, if it were not for the sparking difficulty. Various ingenious contrivances involving parallel resistances, reverse windings, condensers, &c., have been suggested, but they all fail to stand the severe shaking to which any such drill is subjected. Some time ago the writer tried amongst other methods, breaking the circuit in an air-tight box filled with oil; but the intense heat of the induction spark soon carbonised the oil. This experiment, by-the-by, showed the futility of trusting to oil insulation, when it was likely to be pierced by a spark having much energy.

An improvement on this purely electric drill is made by a single solenoid which draws in a plunger against a strong coiled spring. The blow which is given by the recoil of the spring is rapid and resembles the impact of a hammer, if the bit be at the right striking distance; and further the instroke is comparatively slow and does not shake the drill carriage excessively. A spring cushion is provided to receive the blow, in case the stroke be too short to strike the work. Such a drill, designed and patented two years ago by the writer, would have done useful work if the sparking difficulty could have been got over in a simple manner. It must be borne in mind that all direct-current drills are primarily designed to be used on lighting circuits.

A distinct advance on the above mentioned methods can be made with pulsating or alternating currents, or a combination of the two. The most apparent objection, of course, is the restriction of such drills to specially arranged circuits which are not likely to come into general use. The devices which suggest themselves are numerous; but they all have two things in common—(*a*) there is no switch, as the circuits are never opened when running; and (*b*) three or more wires are required.

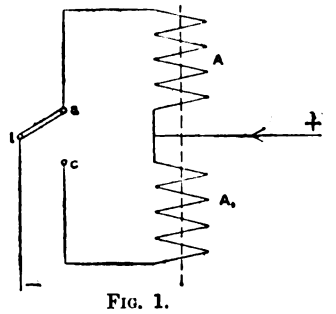

Fig. 1.

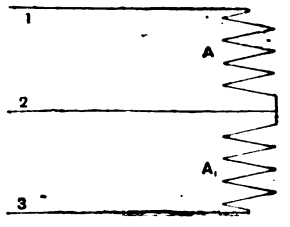

Fig. 2.

The former is a distinct gain, the latter is not so objectionable as it may appear; for if it were intended to work on this principle over a given area, three mains could be run almost as easily as two, and the service wires to the drills could be stranded into a single cable. The simplest drill of this class is one coupled to a di-phase current alternator as in Fig. 2, in which the coils A and A_1 are successively energised. An obvious objection is the fact that the instroke is made at approximately the same rate as the outstroke, and the energy of the movement is nearly the same in either direction. This defect can be remedied to some extent by decreasing the inductive effect of one coil, but it will be at the expense of energy. The Marvin percussion drill is of the double-solenoid type, and is probably the best known in America; it is run off a special dynamo with pulsating currents in separate circuits. The connections are shown diagrammatically in Fig. 3. The armature in its simplest form has only one coil, and one end of this is fixed to a continuous metal ring d_1, on which rubs a brush B_1. The other end of the coil is joined to another piece of metal, d_2, extending over about 180° and concentric with d_1. Two brushes, B_2 and B_3, placed diametrically opposite to each other, rub against it. Three connections are required, B_1 joined to the middle point of the two solenoids, and B_2 and B_3 respectively to each end. It is evident that the two coils will successively carry the current and so give a reciprocating motion. When the brushes B_2 and B_3 are each in contact with

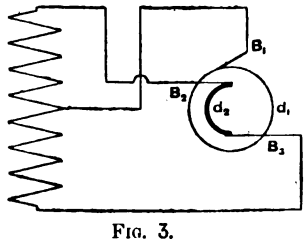

Fig. 3.

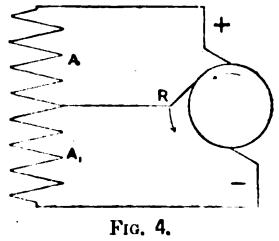

Fig. 4.

d_2, the current will divide itself equally between them (assuming the resistances to be the same) and there will be no tendency to move the drill shaft. By altering the angular length of d_2, the time between the strokes can be varied to suit different purposes. A spring buffer or an air-cushion is used to check the instroke. It is claimed that if the drill be withdrawn out of striking range of the rock, the plunger immediately loses its stroke and comes to rest near the centre of the solenoids. This result is probably attained by opening one of the circuits, and if so it is a doubtful advantage. The writer has used an india-rubber cushion for this purpose.

Mr. W. S. Aldrich recently read a very interesting Paper before the Franklin Institute treating on this subject, and

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giving the results of an elaborate series of experiments with two-coil solenoids. The object of the tests was to show the varying pull in different parts of the stroke, as measured by a spring balance, equilibrium being obtained before taking each reading. He took readings, both with the coils acting in the same direction and with opposing fields. He used an ordinary dynamo, with an additional rotating brush, the arrangement being as shown in Fig. 4.

The brushes + and − are stationary, and from them a direct current flows through A and A_1. The middle wire is attached to the revolving brush *R*. When the three wires are joined the rotating brush causes first A and then A_1 to receive the full potential of the dynamo, and a reciprocating motion of the plunger results.

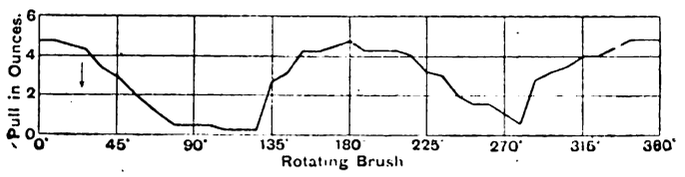

FIG. 5.

Fig. 5. shows the variation of pull through one complete stroke with the fields opposed. Fig. 6 gives the result when the coils act in the same direction.

The curves on the whole are very instructive, due allowance being made for distortions of the integrated curve of potential, caused partly by a variable dynamo speed, and partly by an irregular distribution of potential around the armature. The chief point to notice is that the arrangement shown in Fig. 5. *i.e.*, where the coils are in opposition, gives the most sudden changes, such as are required for hammer-like blows. The Marvin drill has the coils coupled in this manner. When the coils are wound so as to magnetise the core always in the same direction, the heating is undoubtedly less; but the force of the blow is less also, as the impact is not so sudden. This probably points to one of the difficulties fundamental with this class of reciprocating drill.

In order to lessen the force of the instroke with two-coil solenoids, an adjustable resistance may be placed in series with one coil; or one coil may be wound in sections which can be coupled in parallel at the end of a stroke. This latter method requires a commutating arrangement, and has been used, but the writer thinks the complication too great to be effective in practice.

Theoretically, a reciprocating motion for percussion drills is best attained by a combination of pulsating and alternating currents, as used in the Van Depoele drill. One form of the device is shown in Fig. 7. There are two fixed brushes F_1 F_2; and two revolving brushes R_1 and R_2, each pair being separated by 180deg. The coils are three in number, 1 and 3 having few turns relatively to 2; 1 and 3 are in opposition. The connections are as follows:—Coils 1 and 3 are in series,

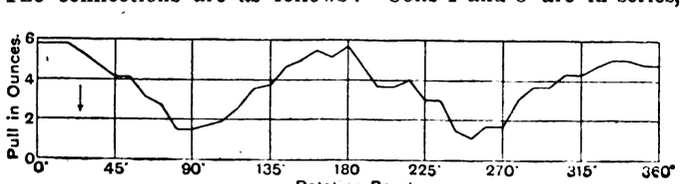

FIG. 6.

and coupled to the revolving brushes R_1 and R_2 of the dynamo; these coils are thus traversed by an alternating current. The coil 2 is coupled to the fixed brush F_1, and at the other end to the junction of coil 3 with the rotating brush R_1; it is therefore energised by a pulsating current, and exerts the chief effect on the plunger *with a constant polarity*. The movement in the direction the blow is to be given is made mainly by the action of the centre coil, the end coils practically neutralising each other. The return stroke is chiefly due to the resultant pull of the two end coils, as the current in the centre one varies between zero and its maximum. At a first glance there seems to be a departure from simplicity of design, without any compensating gain. But on a closer examination it will be seen that the instroke can be made as light and the outstroke as heavy as desired. These two points are of the greatest importance in percussion drills; and, further, the end is attained without any switch arrangement, and with only three supply mains. The writer does not know whether three-coil drills of this type get very hot when running continually; but since the magnetic induction in the plunger, although in one direction as a whole,

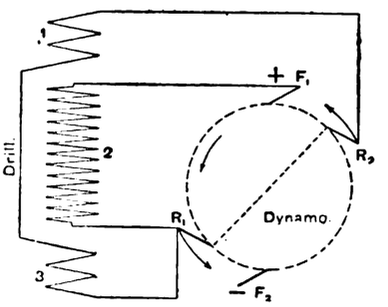

FIG. 7.—Van Depoele Reciprocating Drill

varies between wide limits, the conditions point in this direction. In fact, the iron circuit of a reciprocating drill requires to be thoroughly laminated in order to avoid serious losses from hysteresis and eddy currents; and this important point is not easily reconcilable with mechanical considerations—not to mention the commercial side of the question. The dynamos for this class of work require special modifications, which also, no doubt, introduce a further train of difficulties peculiar to them.

Viewing the percussion rock drill from its present standpoint, the writer is inclined to think that considerable improvement must be introduced before it will be widely used. The theoretical considerations are already developed to a large extent, and the conditions of practice are well known; but the drill of the future is yet to come.

ON THE RETARDATION DUE TO IRON PIPES.

BY W. H. PREECE, F.R.S.

About three years ago, when the working of the electric light installation at the Holborn Restaurant was changed from an isolated plant to the central-station system of the Metropolitan Electric Supply Company, a considerable fall of potential was observed when alternating replaced the continuous currents. This was traced to the choking effect of some iron-cased conductors which were used as service leads. It was easily cured by placing the go and return leads in the same iron casing. Particulars of this experience were not published. A similar effect occurred recently when the City of London Electric Light Company supplied current to Messrs. Mappin and Webb's establishment opposite the Mansion House. Major-General Webber has been kind enough to supply me with full particulars of this experience; and as the effects were traceable to causes which Prof. Ewing had been investigating, and of which he was such a master, I submitted them to him, with the result that he has sent me the following very interesting letter:—

Particulars as to the retardation effect apparent when separate iron pipes are used as a protection for cables carrying alternating currents, supplied by Major-General C. E. Webber.

Alternations	100 complete periods per second.
Size of conductor	19/14 ·0973 sq. in. section.
Insulation	Class K Silvertown overall diam. 0·71 in.
Length of cables	51ft. between the two testing points, making 102 ft. in circuit.
Calculated copper resistance at 60° F.	0·00884 ohm.

Each cable was placed in a separate pipe.

Internal diameter of pipe	1·25in.
External diameter of pipe	1·65in.
Length of pipe	43ft. in two pieces on each cable.

Total length of pipe, 86ft., in four pieces.

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The following tests were made :—

Drop in volts between the two ends of the line.	Load in 60-watt (16-c.p.) lamps at 100 volts.
0	0
2	12
8	43
11	100
13	140
12	140

The two voltmeters used were checked together and found to fairly agree, but owing to the fluctuation of the current at the time no accurate readings could be taken.

"Cambridge, April 16, 1892.

"DEAR PREECE: The fall of potential observed by General Webber in alternate-current service wires when these are laid in separate iron pipes is rather a complicated matter. It admits, however, of tolerably complete analysis by help of the equations lately published by J. J. Thomson (*The Electrician*, April 8th), some of the uses of which were exemplified in a subsequent Paper of mine (*The Electrician*, April 15th).

"Apart from the small drop which is caused by the ohmic resistance of the conductors, there are three things that contribute, as consequences of the sheathing pipes, to bring down the volts at the distant end of the service wires :—

"(1.) First, there is the self-induction of the conductors. The presence of the iron pipes, of course, enormously increases the self-induction, making the cables in the pipes act like choking coils, and reducing the power supplied to the circuit by making the current in them lag behind the E.M.F. in the mains. In other words, the pipes give rise to an E.M.F. of self-induction which opposes the impressed E.M.F. of the supply. This is one reason why the E.M.F. measured between points beyond the sheathed parts of the service lines is less than the original E.M.F. The fall of E.M.F. due to this cause does not in itself imply a waste of energy: it only means that less energy is taken from the mains.

"(2.) Next, there is the loss due to eddy currents in the pipe. The alternate circular magnetisation of the pipe sets up eddy currents in it, and the power which is wasted in these requires that there should be a fall in the voltage on their account.

(3.) "Then, lastly, there is the loss due to magnetic hysteresis in the pipe. This again wastes energy, and requires a further fall in the voltage.

"The three effects may be calculated separately. In calculating the self-induction and the loss due to hysteresis, it has to be borne in mind that the distribution of magnetism is by no means uniform throughout the substance of the iron. With a pipe so thick as the one described by General Webber there is much magnetic screening. The eddy currents prevent the magnetic force from penetrating into the interior of the metal with anything like the intensity which the force has at the skin. J. J. Thomson's expression for the force (H_x) at any distance x from the middle of the thickness of the pipe may be written

$$\mathsf{H}_x = \mathsf{H}_0 \left(\frac{\cosh 2mx + \cos 2mx}{\cosh 2ma + \cos 2ma} \right)^{\frac{1}{2}},$$

where H_0 is the force at the skin, a is the half thickness of the pipe, and m is the quantity $2\pi\sqrt{\frac{\mu n}{\sigma}}$, μ being the magnetic permeability, n the frequency of the alternations, and σ the specific electric resistance of the iron. From measurements and tests of the sample of pipe which you sent here I find that μ is 1,000 and m (with a frequency of 100) is close upon 20. At the middle of the thickness the magnetic force has barely one-thirtieth of its skin value. The mean magnetisation of the pipe is only about one sixth of what it would be if a steady current were maintained in the conductor with strength equal to the maximum strength of the alternating current. The mean magnetic induction in the pipe, to be used in calculating the self-induction of the conductor, is

$$\frac{\mu \mathsf{H}_0}{ma\sqrt{2}} \left(\frac{\cosh 2ma - \cos 2ma}{\cosh 2ma + \cos 2ma} \right)^{\frac{1}{2}},$$

which, in the case considered, is sensibly equal to $\frac{\mu \mathsf{H}_0}{ma\sqrt{2}}$.

"Next, to calculate the eddy-current waste, the rate of dissipation of energy in eddies, per cubic centimetre of the pipe, in ergs per second, is

$$\mathrm{E} = \frac{\mathsf{H}_0^2 m \sigma}{32 \pi^2 a}$$

multiplied by a coefficient, which in the case we are dealing with is sensibly equal to unity.

"To find the loss due to hysteresis, we must first obtain by magnetic tests a set of values of $\int \mathsf{H}\, d\,\mathsf{I}$ for cycles of magnetisation, using various amplitudes of magnetising force. Then, by the expression given above for H_x, find the value which the magnetic force reaches at various depths within the metal, and so proceed to determine a proper mean of $\int \mathsf{H}\, d\,\mathsf{I}$ for the whole of the iron.

"When all this is done the total drop in volts which the iron pipe sheathing may be expected to cause will be found by adding the losses due to these three more or less independent actions.

"I have determined the magnetic constants of the pipe you sent, and have made a calculation of the several effects which, although somewhat rough, is sufficient to show that the sum of the losses is at least of the same order of magnitude as the drop which General Webber observed. It is not, I think, worth while to pursue the calculation further, for the data of the case are scarcely precise enough to make the observation serve well as a test of the theoretical work. The observation is, however, very interesting, not only on the practical side as showing forcibly the necessity of putting both conductors into one pipe, when iron pipes are used to protect alternate-current mains and service wires, but also as giving material for the application of the equations which were published by J. J. Thomson only a week ago. It is a case in which the influence of eddy currents in screening the interior of the iron is so great that any calculation in which consideration of that influence was omitted would quite fail to give even roughly correct results. The eddy currents are in themselves a source of loss, but indirectly they reduce the total loss by protecting the inner parts of the metal from magnetisation. Were it not for this protection the drop in volts due to hysteresial dissipation alone would be greater than the whole drop that was actually observed.—Yours very truly,

"W. H. Preece, Esq., F.R.S." J. A. EWING.

The point that interested me particularly in this inquiry was the effect which this choking influence would have on retarding telegraphic signals and in deteriorating telephone speaking. In long submarine cables the iron sheathing has apparently no retarding effect on the transmission of signals; and this is due probably to its want of circumferential continuity, but with iron piping the form and the effect are different. Here induction and hysteresis will retard the currents and will increase the sum of opposing effects which limit the rate of working. There is a strong tendency to put wires in iron pipes underground to secure safety from wind and snow; but unfortunately this is done at the expense of effectiveness, long lines of iron piping will probably be death to fast-speed telegraphy. Of course, in telephony iron piping is seriously detrimental to single wire working, but then no one would dream of using any but the metallic-circuit system in any underground system.

There is another point for consideration, and that is, may not wood or earthenware or cement replace iron as a conduit for electrical conductors, and be made equally effective from the mechanical and economical point of view?

ANGLO-AMERICAN TELEGRAPH COMPANY.—This Company notify us that on and after May 1st next, the rate for the transmission of telegrams by their lines "*via* Galveston" to all places in the Argentine Republic, Bolivia, Brazil, Chili, Ecuador, Paraguay, and Peru will be reduced to 6s. 2d. per word.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—At a meeting of the Board of this Company held yesterday (Thursday), it was decided that after placing £15,000 to the reserve fund, and £6,293 to the debenture redemption fund, the Directors would recommend at the forthcoming meeting a dividend of 6s. per share, free of income tax, making, with the interim dividend paid in November last, a distribution of £4 per cent. for the year 1891, carrying forward £4,486 to 1892. The bulk of business transacted shows an increase over the corresponding period, but owing exclusively to the large loss on exchange diminishing the receipts, the dividend is reduced.

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AN ELECTRIC TRAVELLING CRANE.

An electrically-driven travelling crane, capable of carrying about 2¼ tons, for loading and discharging large ships, has been built by the Allgemeine Elektricitäts Gesellschaft for the Hamburg harbour quays. It was put in operation in November last, and has continued to work without interruption ever since, in spite of the unpropitious wintry weather.

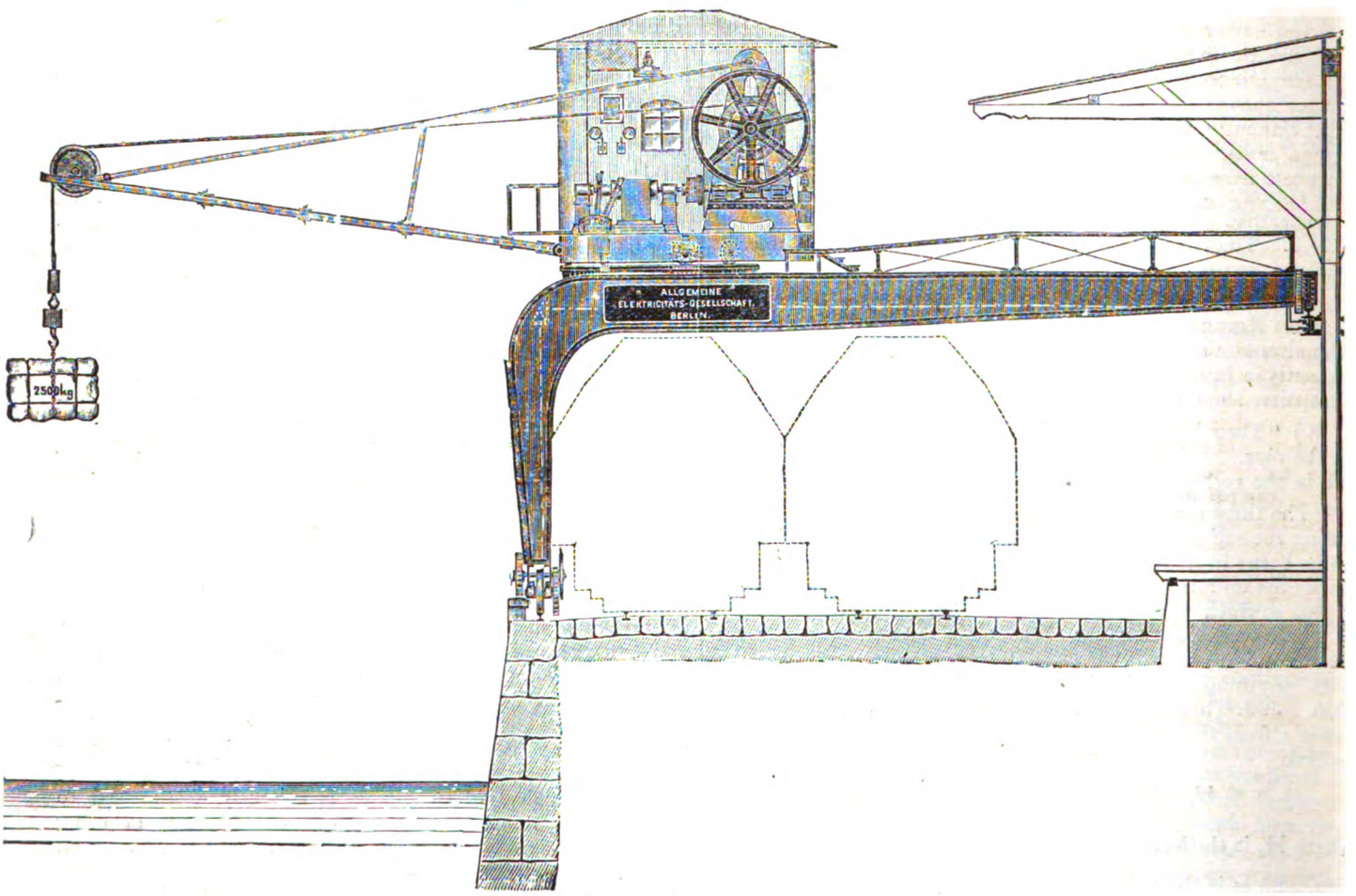
The crane, as shown in the figure, stands upon a traversing framework, which is high and wide enough to permit the passage under it of two lines of railway or waggon traffic, and it terminates alongside a goods shed.

The dimensions and points of its construction are as follows :—

Safe load	2,500 kilog. (nearly 5?cwt.)
Total height of lift	13.75m. (say 45ft.)
Projection of the jib, *i.e.*, distance from the centre of the crane to the centre of the sling hook	10.75m. (35ft. 3in.)
Vertical speed	1m. per sec. (197ft. per min.)
Traversing speed	2m. per sec. (394ft. per min.)

with windows, and mounted upon an iron platform. Each set of these gears is entirely distinct, each having its own electro-motor, and each being controlled by its own particular lever.

The turning of the crane is effected by means of an electro-motor, which drives one of the three guide-wheels under the turntable by worm gear. The worm spindle can be stopped at any moment by a powerful brake actuated by the steering lever when this is in its midway position ; thus the turning motion is controlled with precision. To obviate all liability to damage to the spindles from the swiftly rotating armature, an elastic coupling, a so-called "wire brush coupling" is used, which acts when the brake is applied, permitting the coupled parts to glide past each other and allows the armature to come to rest after a few revolutions. For a similar reason, the above mentioned guide-wheel running on a smooth path was chosen in place of a toothed rail and spur-wheel ; for breakdowns were to be feared with the latter through the rapid turning of the long derrick. There is, however, always a means afforded to the driver of modifying the speed of the crane, inasmuch as the motor is series wound.



2¼-Ton Electric Travelling Crane.

In the construction of the crane it was advisable that wire rope instead of a chain should be used, and in the winding gear spur or bevel wheels had to be avoided for the sake of silent running. The handling of the crane was to be as far as possible like that of hydraulic or steam-power cranes, in which it is possible to raise or lower the load during the traversing of the crane.

The current is brought from the generating station through copper rods carried along the outside of the shed. This station also provides the light for the harbour, and was erected some time ago by the Allgemeine Elektricitäts Gesellschaft ; cables pass through the hollow pivot of the crane and lead to the controlling gear. Around this pivot, which is seated in a turntable, revolves the whole winding and traversing mechanism of the crane, protected by a cabin

The 40 H.P. electro-motor of the hoisting gear is shunt-wound, and connected, like the above, by a "wire-brush coupling" to a worm spindle, which has a powerful brake actuated by the respective controlling lever, as in the former case.

The reversal of the direction of motion is here also attained electrically, viz, by reversing the armature current ; the starting resistance is switched off simultaneously with the movement of the controlling lever, this in its midway position entirely cuts off the current from the motor. By pulling the lever backwards, the current flows first through the field-magnets, then in increasing quantity through the armature, while simultaneously the brake of the worm spindle is released and the load begins to ascend. On the other hand, if the lever is pushed over from the midway position in the forward

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direction the manipulations are the same; but before the armature receives its current the direction of motion is changed, and the whole hoisting gear now runs the opposite way, so that the load descends. The worm now tends to drive the armature, but the shunt-wound motor does not permit it to force it beyond its normal speed; so then the armature acts as an electric brake, and sends the current back into the conductor instead of consuming energy.

To provide against a dangerously rapid descent of the load in the event of a rupture of the circuit through this brake a second electric brake is furnished, which is equal to any possible contingency. Alongside the hoisting-drum round which the wire rope is coiled, and connected to it, is a brake-wheel, the brake-blocks of which are so weighted that they would be permanently pressed against the brake-disc if there were not on the opposite side a powerful electro-magnet to hold them back, so long as it is influenced by the passage of the main current. Any interruption of the main current makes this electro-magnet inoperative, permits thereby the brake-blocks to fall against the disc, and instantly grips the whole hoisting gear, thus preventing further motion.

The advantages of this electric crane compared with a steam crane are considerable. Firstly, the commercial efficiency of electric motors is, on the whole, higher than that of the steam motors of equal power hitherto employed on the Hamburg quays; and with all other motors the efficiency falls off continuously from various causes, viz., the difficulty of keeping pipe joints, &c., tight. Then, the current used by the electric motors remains always very nearly proportional to the demand of the moment; whereas similar economy is impossible with the direct-action steam cranes hitherto in use, because the principle of expansion is not brought to bear in these. Again, with an electric system having proper insulation, the degree of efficiency may always be calculated beforehand, while considerable losses through long steam pipes, especially in winter, in consequence of the cooling in cylinders and pipes, are unavoidable. Lastly, a properly constructed electric system requires but few repairs, and repairs form a big item with steam cranes.

Now that the crane has been working without a hitch during over four of the least propitious months of the year, and has consequently been taken over by the dock authorities, not only may the *raison d'être* of electric cranes be said to have been established, but the realisation of this first attempt must be accepted as evidence of the foresight of the Hamburg harbour authorities, and its prompt and complete success as proof of the skilful design and construction on the part of the Allgemeine Elektricitäts Gesellschaft, whose London representatives are the Keys' Electric Company.

NOTES ON THE LIGHT OF THE ELECTRIC ARC.*

BY ALEXANDER PELHAM TROTTER, B.A.

It is apparent to intelligent observers, and well known to all electric light engineers, that the light of an arc lamp is not emitted uniformly in all directions. Photometrical measurements of arcs are generally expressed by a polar curve, the length of the radius vector representing the candle-power. Although a good deal of work has been spent on this subject, the real meaning of the shape of these curves has not attracted much attention. They all exhibit the same characteristics, and it is easy to notice two distinct types of variation. One variation is found with arcs employing a large current, and consists in the emission of a small quantity of light in a direction above the horizon, the curve rising a little above the horizontal axis. Another type of variation is the narrowing of the whole curve, and the concentration of a large proportion of the light at an angle of about 40deg. or 50deg. with the vertical.

A rather complicated treatment of the subject has been made by M. Rousseaut† with the object of finding a formula for the distribution of the light. His treatment appears to be empirical, and having arrived at a formula he does not appear to have recognised the practical meaning which it contains.

It has been assumed by many persons that the hollowing of the crater of the positive carbon tends in some unexplained manner to concentrate and throw the light downwards. It is evident that the lower or negative carbon intercepts a good deal of the light, but there speculation appears to have stopped. A little consideration will show that the effect is precisely and identically the same as though the end of the positive carbon were flat. No tilting of an incandescent or other luminous surface can make it brighter, and, on the other hand, if it is covered with a thin imperfectly transparent layer, as in the case of the atmosphere of the sun, the edge will appear less bright than the middle of the disc. The quantity of light emitted by an incandescent disc in any direction is proportional to the amount of surface visible from that direction. That is to say, candle-power varies then as the cosine of the inclination.

Cosines plotted as a polar curve give a circle passing through the pole. This theorem is not to be found in mathematical works, being much too easy and simple for those students who have got so far as polar curves. The candle-power of the crater of an arc lamp should then, if plotted as a polar curve, coincide with part of a circle. Any deviation from the circle must have some cause. Two such deviations are observed, and their causes are easily recognised.

An ideal continuous-current arc, in fact any good one with first-rate carbons, has a uniform horizontal crater, and this gives no light in a horizontal direction, though a little may come from the hot sides of the carbon, especially if it is carrying a rather large current. No brightly incandescent surface is seen. The pointed negative carbon is seen in profile, and some light is emitted by it. From what Prof. S. P. Thompson and others have told us of the physics of the arc, it is very probable that the seat of the dissipation of energy is primarily at the surface of the crater. The negative carbon only becomes hot by being cooked in front of the crater. It is wasted, probably, by mere combustion; and even this waste is reduced by the deposition, under some circumstances, of carbon transferred from the positive pole. The waste of the positive carbon is undoubtedly due to volatilisation. Prof. J. J. Thomson and others have shown that electrolysis is not necessarily confined to bodies in the liquid state, and it seems probable that the volatilisation of carbon at the crater and its deposition, under certain conditions on the negative carbon, is closely allied to electrolysis, the positive pole behaving as an anode, both in its wasting and in the fall of volts at its surface. The absorption of energy appears to be twofold. A certain quantity of heat is required to produce the change of state from solid to vapour, and a certain difference of potential must be required to produce the electrolysis. In one of the very interesting articles by M. Palaz,* in which he abstracts and compiles the work of numerous Continental writers, he states, without giving his authority, that 85 per cent. of the light of an arc is emitted by the positive carbon, 10 per cent. by the negative carbon, and 5 per cent. by the flame of the arc. It seems probable that in most cases the proportion of light emitted by the positive carbon is even greater than this. The word "arc" will be used in this Paper as an abbreviation for arc lamp, and will not be used to denote the flame which plays between the carbons. The word "crater" will be used to denote that portion of the positive carbon which is at the highest degree of incandescence. This portion is generally well defined, the colour being uniform. The word "crater" will not be used to signify a hollowing of the carbon.

During the Antwerp Exhibition in 1885, M. Wybauw† made a number of photometric measurements of arcs by different makers. The full curve in Fig. 1 represents the mean of a large number of observations made, no less than 26 different arcs having been tested. The cosine of 60deg., being one-half the area of the crater seen from this direction, is one-half of that of the full circle; the candle-power is one-half of that emitted by the crater; and the length of the radius vector corresponding to 60deg. may be taken as the radius of the circle. The light due to the negative carbon is clearly shown as an excess above the circular curve; there is, indeed, nothing else to which it can be due, except the red-hot walls of the crater.

At about 60deg. the curve of candle-power begins to fall off, and this is due to nothing else than the shadow of the lower carbon, which intercepts more and more of the light as we pass to smaller angles, until, if the carbons be of the same diameter, no light is thrown in a vertical direction.

In considering the real meaning of the latter part of the curve, the author drew a number of views of a pair of imaginary carbons, projected at different angles. The elliptical area of the crater in each view was calculated, and he found that these areas, plotted as radii of a polar curve, gave a curve closely resembling the well-known candle-power curve of the arc. It follows that if this be proved to be true by experiment, the candle-power per square millimetre of the crater is constant.

The author communicated this result to Prof. S. P. Thompson, and asked if he would see whether actual experiment would confirm it.

* Paper read April 28, 1892, before the Institution of Electrical Engineers.

† *La Lumière Electrique*, Vol. XXXVII., p. 415.

* *La Lumière Electrique*, Vol. XXXVII., p. 410.

† *La Lumière Electrique*, Vol. XXXVII., p. 414; and Vol. XXVI., p. 58.

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A series of very interesting experiments has been carried out at Finsbury Technical College by Mr. C. F. Higgins, senior student. A "Planet" lamp, taking 8 or 9 amperes, was first employed, and the first experiments showed that the light was undoubtedly proportional to the area of the crater. In order to carry out the

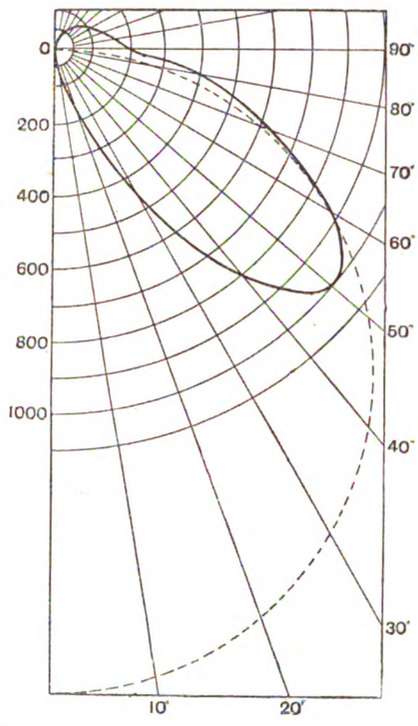

FIG. 1.

experiments with greater accuracy a larger lamp was required, and Messrs. Johnson and Phillips kindly lent a Brockie-Pell lamp, taking 25 amperes. The following apparatus (Fig. 2) was constructed by Mr. Higgins at the workshops of Finsbury College, for the purpose of projecting an image of the arc :—

An arm adjustable on a horizontal axis, and provided with a clamping nut and graduated arc, carries a lens and a mirror set at an angle of 45deg., with the direction of the ray of light falling

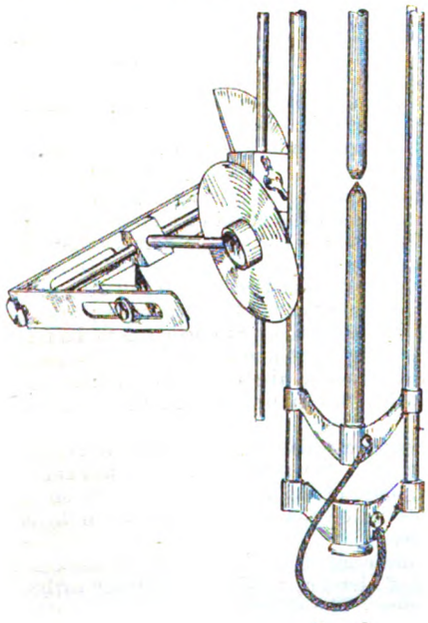

FIG. 2.

on it, and reflecting the ray in a direction parallel with the axis of the radial arm. An image of the arc may thus be projected on a screen. As the radial arm is moved the image turns round, but this does not interfere with the observations. An Ayrton-Perry photometer, slightly modified, was used to measure the light with a standard candle, and this was done by removing the projecting lens, and allowing the reflected beam to fall on the mirror of the photometer. When the lens was replaced for the purpose of projecting the image, the mirror of the photometer was removed, the rest of the photometer remaining undisturbed. The image was received on a sheet of drawing paper and was amplified about 14 times. The outline of the incandescent crater was traced in pencil, and in some cases an outline of the carbons was drawn.

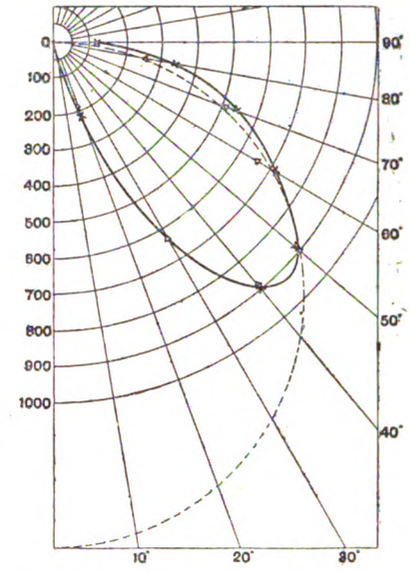

FIG. 3.—Curve of areas of crater and candle-power of normal arc. Δ = area and × = candle-power. The scale of radii is arbitrary.

The diameter of the carbons formed a standard for absolute measurements. Readings were taken at every 10deg. inclination. The area of the tracings was measured by a planimeter.

In the first experiments the absorption of the two mirrors of the photometer was neglected, and the results are not, therefore, to be taken as candle-power. The mirror on the radial arm was of platinised glass, since an ordinary mirror gave a double image. The reflecting power was not good, though the image was clear. The areas were also measured to an arbitrary scale at first. Figs. 3 and 4 give polar curves of two sets of observations. The photometer readings are represented by circles, and the areas by triangles. A general coincidence of both sets of observations with the well-known curve is evident. Figs. 5 and 6 are reproductions of the tracings.

It is rather difficult, in many cases, to estimate the relation between two polar curves by mere inspection, partly perhaps

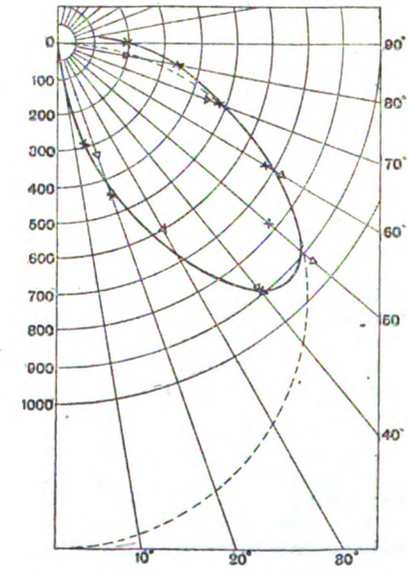

FIG. 4.—Curve of areas of crater and candle-power of short arc. Δ = area, and × = candle-power. The scale of radii is arbitrary.

because they are so seldom used in practice. Two different curves may be drawn, the one through the photometer readings, and the other through the areas of crater ; but, owing to the difficulty of arriving at accurate results, on account of changes in the length of the arc, which greatly affect the inner part of the polar curve, and the occasional indistinctness of outline of the crater, the errors of either set of readings are probably as great as their departure from the curve drawn freely among the two sets.

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Useful as it is to plot as a polar curve observations which relate to measurements taken at different angular directions, the relation between the two sets of readings may be examined more easily when they are plotted with rectangular co-ordinates. (Fig. 7).

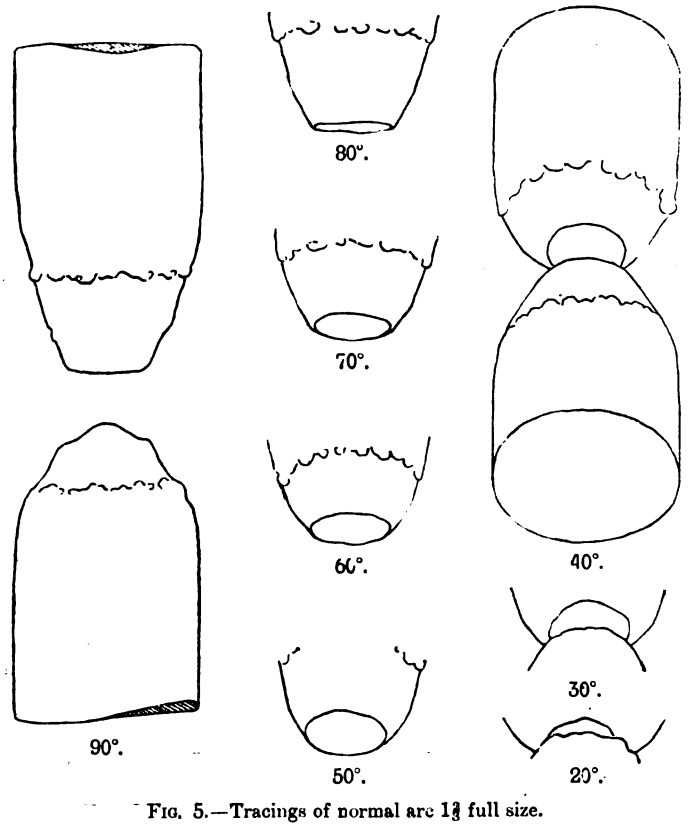

Fig. 5.—Tracings of normal arc 1⅜ full size.

A straight line cutting the axis at 100 c.-p. seems to fit the results. This may be explained by the light which is emitted by the red-hot and glowing parts of the carbon. These were not included in the measurement of areas, the true crater only was measured. The

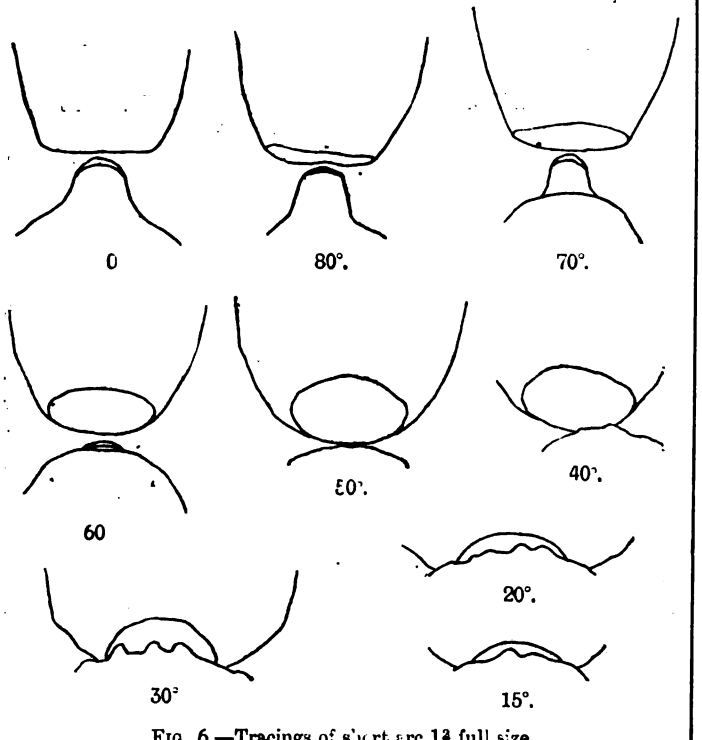

Fig. 6.—Tracings of short arc 1⅜ full size.

author has been unable to carry out any complete experiments on the photometry of arcs, the present Paper is only a collection of notes on the subject, which is treated qualitatively and not quantitatively. The measurements, for various reasons, were relative, and attempts were made on one occasion only to take direct readings in candle-power. The image of the crater at 60deg. was projected and traced, and measured by a planimeter. The mean of several fairly concordant readings was 20·8 sq. in. The diameter of the image of the carbon was 17in. Its actual diameter was 0·6in. The image was therefore magnified 28·3 times. The real area of the crater was 0·025 sq in. The candle-power readings were taken at the same angle, and immediately after the tracing of the image in each case, being measured directly from the arc without reflection. They were fairly concordant, and gave a mean of 1,065 candles. At the maximum position (about 45deg.) this

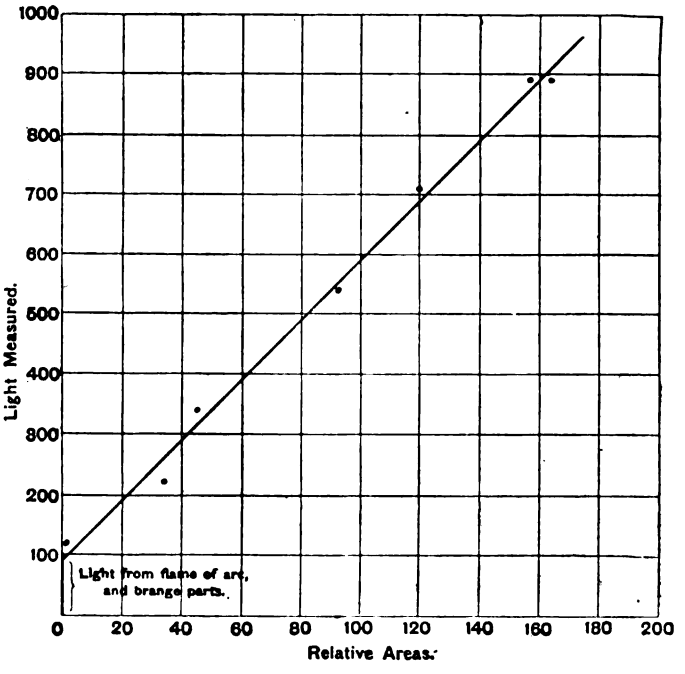

Fig. 7.—Areas of crater, and light of normal arc.

would give about 1,400 candles. It follows, therefore, that the crater gave 42,600 c.p. per square inch, or 64 c.p. per square millimetre. The amperes were 26, and volts 51.

It is as impossible to raise carbon above the degree of incandescence of the crater of the arc as it is to raise water above boiling point or ice above melting point.* No substance has yet been suggested for "improving" arc-lamp carbons, which is less volatile than carbon. Even the core of cored carbons, while it serves a very useful purpose in steadying the arc, is less brilliant than the rest of the crater. If a lower temperature than the normal incandescence be found at the crater, it is because the positive carbon is too large for the current. Under these circumstances the arc generally flickers irregularly, and a highly-incandescent patch travels about over the surface of the crater.

The large amount of light intercepted by the negative carbon raises the question: What becomes of it? It is evident that it strikes the lower carbon, and is probably converted into heat; but since only about 10 per cent, of the whole radiation of an arc is in the form of light,† most of the "cooking" of the lower carbon is done by mere heat.

It is not difficult to reconstruct the shape of the carbons, which must have given rise to the curve given in Fig. 1, but to do so is nothing more than a geometrical exercise, and leads to no useful result. A similar relation obtains between the candle-power-curve of an alternating-current arc and the shape of its carbons, but the use of alternating arcs is not common; the light is not, for outdoor purposes, thrown in a useful direction, it is difficult to prevent the arc from flickering round the carbons, and they give so much trouble from other causes that they are seldom worth using.

(To be continued.)

* S. P. Thompson, Society of Arts, March 6, 1889; *The Electrician*, Vol. XXII., p. 534.

† Prof. Marks, American Inst. Electrical Engineers, Vol. VI.; *The Electrician*, Vol. XXV., p. 150, *et seq.*

Royal Society.—The following Papers were down for reading yesterday before the Royal Society:—The Lord Kelvin, P.R.S., "On a Decisive Test-Case disproving the Maxwell-Boltzman Doctrine regarding Distribution of Kinetic Energy." A. McAulay, "On the Mathematical Theory of Electro-Magnetism." W. J. Dibdin, "Stellar Photometry." John Aitken, F.R.S., "On some Phenomena connected with Cloudy Condensation."

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THE PRACTICAL OPERATION OF THE GEARLESS MOTOR.*

BY S. H. SHORT.

At first thought it does not seem necessary to place on the market a motor of new design which involves the abandonment of gear wheels for transmitting the power of the armature to the axle; but when we consider it carefully, and examine all the advantages to be gained by so doing, we feel justified. While the single reduction type of motor is undoubtedly eminently successful, I believe we can go a step further with great advantage, that we can connect the armature directly to the axle of the car, without the intervention of armature, intermediate or other kind of gears. The abandonment of gears, or a "gearless" motor, is undoubtedly absolutely necessary where high speed is required for driving trains of cars upon suburban or interurban lines—a thing which we shall undoubtedly be called upon to do within the near future.

Those of you who have operated electric street car lines can appreciate what a serious thing it is for a tooth to break out of a gear in a car motor while it is in service. Again, it is a great source of loss to a street railway company when it is necessary to take a car out of service to replace worn-out gear wheels. A car earns on an average in a good street car city about $20 per day. If the car is taken off the road for half a day or a day, we not only lose the cost of the repairs, but we lose the profits on the day's run. The causes which disable cars should be reduced to the minimum, and it is to this end that we are advocating the use of no gears in a street car motor. It is very seldom now that we have trouble with armature bobbins and field-magnet spools burning out. While we had some difficulty of this kind in the early days, we have learned how to insulate and protect the motors for street car service, so that electrically they are quite equal to the work they are required to do. We have, therefore, to look more carefully to the mechanical construction of a street car motor, and perfect that part of the machine.

We will now take up the matter of the power lost in spur gearing, and see what we can gain in that direction by abandoning gears. When we first took up the subject of a gearless motor, we set about to see how much could be gained in the efficiency of transmission of power by doing away with the gears. I made a very careful and thorough investigation of the losses between the armature pinion and the intermediate gear, and between the intermediate pinion and the axle gear, of a double reduction motor. I first put a double reduction motor in good order, eliminating the armature bearing losses as much as possible, by running the motor for a long time, to wear the bearings down to a good surface. I put my power brake for determining the H.P. directly on the armature shaft, and ran my motor, delivering different H.P.'s all the way from no H.P. to its full output—20 H.P. At the same time we measured the E.H.P. which was being put into the motor, and from this we constructed a curve of efficiency of the motor at different loads, which curve is reproduced as the upper curve in Fig. 1. The greatest efficiency reached by this motor was about 70 per cent. at a load of from 14 to 16 H.P. The efficiency at small loads, say at 2 H.P., was something like 50 per cent. at 4 or 5 H.P. an efficiency of 65 to 70 per cent.

We then took the brake from the armature shaft and replaced it with a well-made armature pinion, allowing it to mesh with a well-made intermediate gear, these gears being cut as nicely and as carefully as possible, so that there would be the least possible loss between the two in making this test. Putting the brake on the other end of the intermediate shaft we again secured the number of readings of the H.P delivered, after being passed through this one pair of gears, the E.H.P. being indicated carefully at the same time. From the efficiency at different H.P.'s thus obtained we produced a second curve, which is shown in Fig. 1 as the middle curve on the diagram, and we find that the efficiency of this arrangement has fallen considerably. We once more removed the brake and placed the intermediate pinion on the intermediate shaft, allowing it to mesh with the axle gear. The brake was now placed on the axle itself, and another set of measurements—the same as those before made—were secured, and a curve of efficiency again plotted, which showed a large loss in these gears, the efficiency at the axle being less than that at the armature by an amount indicated by the two outer curves. The results showed that at 14 H.P. delivered by the motor we obtained an efficiency of 70 per cent. as a maximum when the brake was placed on the armature shaft. When the brake was placed on the intermediate shaft delivering 14 H.P. the efficiency dropped to about 62 per cent. When placed on the axle, the efficiency dropped to a little less than 55 per cent., showing a loss in the gears of some 15 per cent., when delivering at 14 H.P. You will find in going over these curves that the loads vary considerably with the speed. Making an efficiency curve of the gears alone at different speeds, you will find the efficiency is very low at heavy loads and slow speeds, and rises to its highest at medium speeds and medium loads. It again falls when running up to higher speeds. For this reason it is more economical to run a geared motor not too fast or too slow, but at a medium speed. This fact has been established long since in the use of gears in other classes of machinery, and in designing machines where power must be transmitted through gears the best possible speed at which gears are to be run and the relation between pinion and gear are carefully considered. In the single reduction motor we regain, we might say, more than half of this loss in efficiency, because the gears are run at a moderate speed. I think that this one feature of gear loss makes it desirable to abandon their use in street car motors if possible. If we can save in practice 15 or more nearly 20 per cent. of the power consumed in operating a street car motor, by using the gearless instead of the double reduction type, it is well worth while, as this means the consumption of less coal and the reduction of first cost in the power plant and accessories.

Another set of curves was developed in the same way as those shown in Fig. 1, three motors being used in the test—the double reduction, single reduction, and the gearless. From these curves* it was seen that the efficiency of the gearless motor at the axle, when delivering 14 H.P., reached very nearly 70 per cent., or very nearly the same efficiency as the double-reduction motor at the armature shaft. The single-reduction motor, when delivering the same power through one pair of gears, showed an efficiency of 60 per cent., while the double-reduction showed a little over 50 per cent. These practical tests show that with the gearless motor we actually save from 15 to 20 per cent. in the power it is necessary to put into the car in order to get the same result at the axle.

We will now give you a description of the construction of our gearless motor. Gearless motors have heretofore, as you well know, been constructed and operated. The armature has been placed directly on the axle, and fairly good results have been

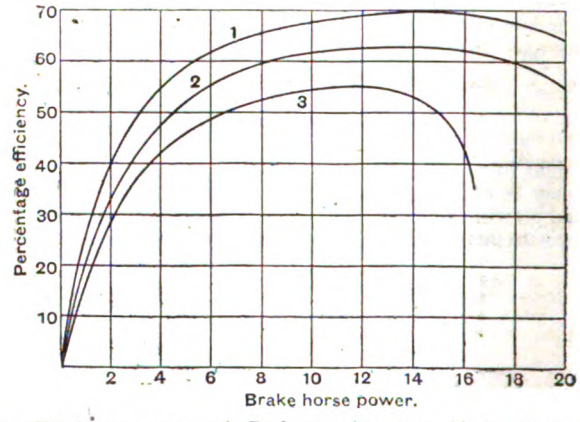

FIG. 1.—Efficiency curves. 1. Brake on Armature Shaft; 2. Brake on Intermediate Shaft; 3. Brake on Axle Shaft.

obtained. The City and South London Railway in London is operating its road with gearless motors to-day. These motors are high speed, making the problem somewhat easier. It is, however, difficult to construct a small motor, not too large to be placed under an ordinary street car, the speed of which shall not be above 105 to 150 revolutions per minute. Because of the light construction of the road-bed in street railways it is also necessary to avoid the heavy hammer blow which occurs at the rail joints from a motor partly or entirely carried on the axle. When the wheel of the car passes from one rail to another it falls, striking a very heavy blow. If we have a weight directly attached and carried on the axle, without any intervening cushion or spring, we will have a very severe sledge-hammer blow on the rail at every joint. This will soon pound out and destroy the rails.

You are all familiar with the difficulty which is experienced in keeping up the rail joints on an electric line. The reason for this is apparent, if we think a moment, as it is a new element which has made its appearance since the introduction of the electric motor. All geared motors are supported at one end directly on the axle, by means of axle bearings. At the other end these motors are supported on springs; thus one-half the weight of a geared motor is carried directly to the car axle without the intervention of any flexible material. The actual weight carried by a set of wheels on the rails does not seem to affect the joints materially. Old horse cars even when carrying heavy loads of passengers, did not affect materially the rail joints. Cable cars do not destroy their tracks, no matter how great their loads. Therefore it must be that this heavy weight of the motor carried solidly on the axle is the thing that is breaking down the rail joints on electric lines.

* Abstract of a Paper read before the Chicago Electric Club.

* These curves being, of course, practically identical with those of Fig. 1, it has not been thought necessary to reproduce them.—ED. *E.*

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This heavy jarring also crystallizes the axles, and we have complaints from all over the country that axles on motor cars are breaking. When we come to examine these breaks we find that the iron has crystallized, and the manufacturers are now endeavouring to overcome this by increasing the size of the axles. With the gearless motor, as we now construct it, none of the weight is directly carried on the axle. The armature is mounted on a hollow shaft which surrounds the axle, leaving an air space of about an inch entirely around the axle. This hollow shaft is really the armature shaft of the motor, and is carried in its own independent bearings in the motor frame. The motor frame consists of a box made in two halves. These two halves are fastened together, and contain the field-magnets and enclose the whole, protecting it from mud and dust, the only opening in the box being on the upper side next to the car floor. This box, which makes the complete motor when assembled, is provided with three projections at right angles to the armature shaft. These projections are made to receive steel spiral springs, similar to car springs. These springs are supported on the cross girders of an ordinary truck, such as is commonly used for motor cars, and support the entire weight of the motor. The axle is passed through this hollow armature shaft, and can move freely in any direction within it. At one end of the hollow armature shaft is placed the flexible driving device which communicates the motion of the armature directly to the axle. The axle has a free end play of 2in. through the motor and armature shaft. This is necessary in rounding curves and to ensure freedom for the movements of the truck.

When the wheels drop from the end of one rail to another the motor does not immediately follow, its inertia being so great. The wheels not being very heavy, do not make a heavy blow, but by the time they have reached another portion of the rail the motor falls down against its springs, distributing, as it were, the blow over a considerable length of the rail, thereby preventing serious damage to the rail joint.

Gearless Motor Trial—Aug. 17, 1891—in Regular Service pulling Trail Car—Temperature equals 96° F.

Time	Amps.	Volts.	Remarks	Time.	Amps.	Volts.	Remarks.	Time	Amps.	Volts.	Remarks.
2:20	33	448		2:46½	16	400		3:13	30	412	
	31	420		7	18	424			0	420	99 amps.
1	19	424			18	440		4	50	412	to start.
	0	428		8	27	428			0	436	
2	30	416			0	400		3:15	47	420	
	55	400		9	23	400			64	416	
3	19	424			0	420		6	21	420	
	17	436		2:50	51	400	Start		19	420	
3	...	...			20	380	@ 96° a.	7	16	420	
	...	...		1	60	360			16	436	
2:25	16	440			33	396		8	14	420	
	0	460		2	0	400			14	420	
6	0	440			60	404	Start	9	15	420	
	16	448		3	20	420			16	424	
7	21	448			0	480		3:20	30	436	
	17	444		4	0	360			0	440	
8	15	424			19	416		1	35	440	
	15	424		2:55	59	331			27	428	
9	0	420			44	436		2	25	420	
	0	444		6	50	380			0	420	
2:30	18	436			0	400		3	56	448	
	19	436		7	0	0			0	460	
1	31	440			20	360		4	41	440	
	28	440		8	0	360			30	460	
2	14	440			70	320		3:25	27	448	
	0	440		9	17	400			22	440	
3	18	448			...	...		6	27	444	
	19	460		3:00	...	...			24	460	
4	17	456			...	...		7	15	440	
	17	460		1	27	368			14	448	
2:35	0	460			27	380		8	22	440	
	20	460		2	0	380			27	440	
6	70	460	Start.		21	404		9	16	460	
	32	456		3	0	380			0	460	
7	24	460			59	360		3:30	0	456	
	40	416		4	41	356			0	440	
8	57	400			20	380		1	18	420	
	26	436		3:5	45	396			39	430	
9	77	420	Start.		54	360		2	40	420	
	85	420		6	0	426			16	430	
2:40	0	440			72	408		3	17	424	
	37	420		7	31	380			25	420	
1	16	448			20	396		4	27	440	
	15	440		8	0	420	70 amps.		16	420	
2	24	420			55	400	to start.	3:35	68	420	Start.
	14	424		9	15	408			40	440	
3	16	424			20	408		6	40	416	
	55	420	Start.	3:10	38	400	80 amps.		35	420	
4	20	440			41	396	to start.	7	15	400	
	0	420		1	55	400			16	416	
2:45	0	420			31	420		8	31	420	
	0	436		2	27	408			35	412	
6	31	430			70	380		9	0	440	

It is contended that in a geared motor we have an enormous leverage through the gears. If we had a small armature, the same as is used in the geared motors on the axle, we should not, of course, be able to start the car, or to do the work necessary in moving a loaded car; but we have a large armature placed in a very strong magnetic field, and we have a great many more turns of the same current around the armature, thereby gaining a greater leverage, because of a larger diameter of armature and a greater pull at the end of that lever. Air resistance we are liable to, the greater loss in the dead resistance of the motor, but by designing our motor with a very low resistance magnetic circuit we are able to cut down the wire on the machine so that its resistance is quite low, being only about 2½ ohms. There is another advantage in this low-speed motor, which is not small; the wear on the commutator is very light, and the heat produced by the friction of the brushes on the commutator is exceedingly small, making the motor run cool in all its parts. We are obliged, of course, to take advantage of everything that is possible in the construction of the gearless motor, in order to make it small and light enough for street car service. We use the best wrought iron and steel in its construction, because of their superior magnetic qualities. We have to use the best copper of highest conductivity to reduce our resistance losses. This, of course, is in the end an advantage to the machine, because it makes it stronger and less liable to breakage.

To answer the question as to how much current is taken by the gearless motor in operating a car, we have prepared a copy of readings taken from a car in actual service, drawing a trail car. The current readings, also the pressure readings, were taken every half minute, and from the table a very good idea of the amount of current required can be gained. These readings were taken in August on the East Cleveland Railroad, Cleveland, O. On this road the traffic is very heavy, although the grades are light. We have carefully tested double reduction, single reduction, and gearless cars running on the same track on roads in Cleveland, O., taking at the same time readings of current and pressure, and we have found that in some cases the single reduction would require

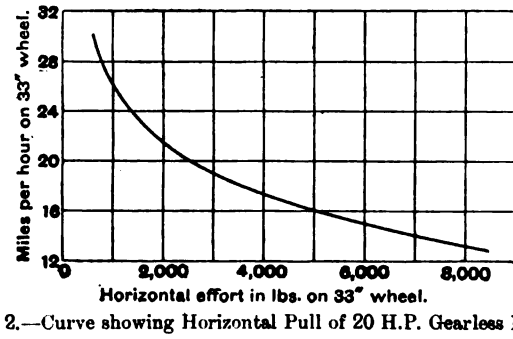

FIG. 2.—Curve showing Horizontal Pull of 20 H.P. Gearless Motor.

the least amount of current, sometimes the double reduction and sometimes the gearless, depending upon the number of passengers hauled, stops made, and other things that might come in to consume more or less power; so it is difficult for us to say that there is any difference in actual power consumption between the three classes of machines.

The gearless motor is capable of starting loads as quickly as the geared motor, and is capable of starting as heavy a load under similar conditions, and we have a curve shown in Fig. 2 which illustrates the actual horizontal pull of a 20-H.P. gearless motor, mounted on 33in. wheels. In examining this curve it will be seen that the horizontal effort in pounds when the car is running 20 miles per hour is about 250. In ordinary street car practice we find that it requires about 20lb. per ton to move a load on street car rails. This means that with a horizontal pull of 250lb. this single motor could move a car weighing 12 tons at the rate of 20 miles per hour, or, as the curve will show, that at 14 miles per hour the motor has a horizontal pull of 700lb., or it will move a load of 35 tons at the rate of 14 miles per hour on a level track. This curve is not falling off rapidly, certainly not as rapidly as it would with a geared motor, because the loss in the gears begins to increase very rapidly with the heavy loads. You can easily figure from this curve what the motor will do under any conditions of load, grade, and speed. The tendency in street-car practice is to increase the speed of the cars; and the gearless motor lends itself especially to this end, as we have found that with very rapid speed geared motors wear out the running parts more rapidly, and become very much more expensive to maintain. While the gearless motor can operate with as great economy at the slow pace required in crowded streets it is also capable of running at a very much higher speed in suburban traffic without the slightest fear of damage to the machine. In this respect it makes a very much more flexible motor than the geared machines. You can easily understand that this motor now makes

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it possible for us to develop large electric locomotives to be used in elevated railway service, and for pulling suburban trains in and out of large cities. From calculations and designs which we have made, we find that the size and weight of the motors required for 200 and 400 H.P. locomotives is not more than is necessary to produce the required adhesion to the rails needed for the required tractive pull to move these heavy trains. The motors are not large comparatively, and their economy will be very great. We believe that this branch of electric railroading will develop rapidly, and that within a few years gearless electric railway motors will be used in places, for purposes, and in numbers unthought of at the present time.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—TUESDAY, APRIL 26TH.

Coast Communications.

Sir E. BIRKBECK rose to move the following resolution standing on the paper in his name: "That, with a view to the better prevention of loss of life and property in cases of vessels in distress or shipwrecked on the coast of the United Kingdom, and to give the earliest possible information to lifeboat authorities and rocket-apparatus stations, in the opinion of this House it is desirable that all coast-guard stations on the sea coast and signal stations should be telephonically and telegraphically connected by Government, and that on those parts of the coast where such stations do not exist, the post-offices nearest to the lifeboat stations be telephonically or telegraphically connected; and that a Royal Commission be appointed to inquire into the desirability of connecting certain light-vessels and rock lighthouses by cable with the mainland in order to give information of vessels in distress."

It would be a matter of general surprise that Great Britain was so behindhand in the adoption of means for the better preservation of life and property at sea. The responsibility for this question of loss of life had been shunted from one Government department to another. Great Britain was in the unfortunate and humiliating position of having to admit to the world that Denmark, with her import and export trade of only 30 millions, had carried out successfully a system of coast communication, while she herself had done nothing, though her import and export trade amounted to 743 millions.

In the resolution he had divided the question into two parts. The first referred to coast communication proper, and the second to communication by cable with the floating light-vessels and rock lighthouses. As experiments had been carried out with reference to the latter subject, he would deal with that first. Communication with the outlying light-vessels and rock lighthouses involved serious engineering and financial questions; and, therefore, it ought to be considered in the first instance by a Royal Commission. The practicability of this communication had been absolutely proved; and cable communication with the Sunk light-vessel, off the Essex coast, was established in December, 1884. In 1887 the then President of the Board of Trade appointed a Departmental Committee to inquire into the advisability of continuing cable communication with the Sunk lightship. He himself served on the Committee, and, together with Colonel King-Harman, found himself in a helpless minority. He was obliged to draw up a minority report because the Committee decided that the maintenance of the communication was not desirable, it having involved considerable expense and produced but little result in the saving of life. He had never regretted his action in that matter. He strongly declared his opinion at the time that the experiment ought to have been carried out for a further five years, and that Parliament ought to have voted a further sum for experiments. During the trials that were made, there were no bad gales, and exceptionally few cases of disaster on the neighbouring sands. The Trinity Corporation were adverse to the experiment because they thought the money might be better spent; and they were particularly influenced by one fact which was brought out in evidence. On one occasion the lightship was hailed by a passing vessel, the master of which, a newly-married man, desired that a private message should be delivered to his wife on shore. It was, however, clearly proved that the officers of these lightships were perfectly capable of undertaking the entire duty of working cable communication. In case of snowstorms or fogs, when rockets could not be seen from the mainland, the officer in charge of a light-vessel could tell the exact position of any ship in distress, and thus serious delay in sending aid was avoided. He quoted extracts from telephonic messages which had been received on the mainland through the Sunk cable, in which the exact position of the vessels in distress was clearly described, and called attention to several cases in which the existence of coast communication would in all probability have prevented serious loss of life.

The question as to which light-vessels and rock lighthouses ought to be placed in telegraphic communication with the mainland was a matter for inquiry by a Royal Commission. The Fastnet, the Tusker, the Eddystone, and other rock-lighthouses were undoubtedly all points of very great importance; and as regarded the Fastnet, where the communication had been broken, the evidence given before the Departmental Committee of the Board of Trade proved that there was no difficulty whatever, from an engineering point of view, in carrying out this proposal.

He had taken up the question of coast communication proper on behalf of the lifeboat service and the rocket apparatus service, because it had too often occurred that when the lifeboat or rocket apparatus got to the spot where a wreck had taken place they found only pieces of the wreck left, and possibly the dead bodies of the crew. There had been instances in which as many as six lifeboats had gone out to one case of distress, when, if there had been cable communication, it was probable that only one lifeboat need have gone out. Then it was necessary to consider the case of a steamer or vessel passing a headland and being sighted from the lighthouse where men could see that she was being driven before the wind and was approaching too near the shore. It might then be too late to get out the adjacent lifeboat, because the vessel would be driven too far for the lifeboat to reach her in time; but if there were another station 10 miles off a telegram or telephonic message would secure the launching of the lifeboat there or the sending of tugs to assist the vessel in distress. This winter off Lundy Island a steamer ran aground in a snow storm on a Friday morning, and the fact was not known on the mainland till Sunday, but in the interval those on the steamer had been rescued by the throwing of lines. Still, the fact remained, and it was important from a commercial point of view, that there was no communication with the mainland between Friday morning and Sunday.

The members of the House who represented the naval service would admit the importance of this question to the Navy. The Duke of Edinburgh, on terminating his command of the Naval Reserve, wrote an important despatch, calling attention to the absolute necessity of having communication between all the coastguard stations on the coasts of the United Kingdom. The present First Lord of the Admiralty had added upwards of 100 stations to the 50 that were in existence before; but, although the Admiralty could boast of 160 stations which were now in telegraphic communication, the fact must be realised that it was only during the naval manœuvres that the communication was open all night and all Sunday; during the remainder of the year the communication was open only between 8 a.m. and 8 p.m. and for two hours on Sundays. It would be remembered that one of Her Majesty's ships coming from Ireland to Plymouth, and being caught in a gale of wind, took refuge under Lundy Island, and as no intelligence was received of her whereabouts, vessels were ordered out from Plymouth in search of her. This action, and the anxiety out of which it arose, would have been avoided if there had been communication between Lundy Island and the main land. Whether it was for the saving of life and property, for the promotion of shipping and commercial interests, for facilitating naval movements, or for assisting our fishing industry, coast communication was all important.

Denmark had set a bright example. On the coasts of America the facilities of communication had been the means of saving many lives. All the lighthouses of Holland were connected with the mainland by wire. The Cape of Good Hope had five lighthouses with telegraphic communication. The Indian Government had carried out this policy, and many other countries had done so. He could quote cases in which most disastrous loss of life had occurred round our coasts where the calamity would have been avoided, or greatly mitigated, had telephonic communication existed. The superintendent at Lloyd's gave evidence before the Board of Trade Committee in 1887 to the effect that there was a number of their signal stations that had been the means of saving life. The Deputy Master of the Trinity Corporation, Sir S. Webb, in giving evidence before a committee of the Lifeboat Institution, gave it as his opinion that there was no reason whatever, where a lighthouse was situated at any point where it was likely to give intelligence of a vessel being in distress, why one of the hands belonging to the lighthouse should not immediately telephone the fact to the nearest post station, whence it could be communicated to the nearest lifeboat station. In order, however, to make coast communication effective, it was absolutely necessary that telegraph offices should be open during the whole 24 hours every day of the week, Sunday included. The system ought to be as effective as the fire-escape system of the metropolis was. The evidence was overwhelming as to the necessity of coast communications; and whether it cost £50,000 or even £200,000 to set them up, that was a minor matter in comparison with the better preservation of life and property at sea. The British sailor looked to the House of Commons to provide further means for the safety of life. He knew the fishing industry looked forward with great interest to what the House of Commons was going to do with regard to this matter The commercial community regarded the question as one of very great importance. Over 60 Chambers of Commerce had passed resolutions in favour of coast communications being carried out. He had not heard of one person, whether in the House or out of it, who had ever said a word against it, and therefore he hoped the House would come to a unanimous resolution in favour of the motion. He appealed to the House of Commons, by accepting the resolution, to put an end to the degrading position this country had so long occupied in connection with this matter. He begged to move the resolution which stood in his name.

Mr. MARJORIBANKS, in seconding the resolution, said they ought to be quite as prompt in providing for the protection of life and property from the winds and waves as they were in providing protection from fire.

Sir J. FERGUSSON remarked that it would be easy to exaggerate the good that could be done by connecting every coastguard station with the telegraph. Recognising, however, the necessity of communication with exposed parts of the coast, they had at some labour framed an estimate of the cost necessary to give telephonic communication with the coastguard stations from the Isle of Wight to Lynmouth in North Devon. That covered a considerable portion of coast to which attention had been called of late years, and included connections with outlying islands, such as Scilly. The estimate for this was over £16,000. The work of framing estimates for communication all round the coast would be continued. The fact that the matter was in the hands of the Post Office showed that it had gone beyond the stage of contemplation, and that steps were being taken to carry it into execution.

There were some stations in very exposed situations where ships were particularly liable to be stranded, and where it was very necessary that there should be means of speedy communication with life-saving stations. Her Majesty's Government proposed to proceed at once with the erection of wires in such places; surveys of several of these works of a pressing

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kind were in progress, and something would be immediately commenced. In addition to this, a rough estimate had been made of the cost of establishing telegraphic communication with lighthouses and lightships, which came to about £300,000.

The hon. member for East Norfolk spoke about this country being so far behind other nations in the matter of electric communication with lighthouses and life-saving stations; for his own part he did not think that we were so far behind as was commonly supposed. In the first place, a great many of our coastguard stations were already in communication with a telegraph station, and very many more were close to one. Her Majesty's Government, however, would not think of what other nations did. Great Britain was the greatest maritime nation, and therefore there was every intention on the part of the Government to meet this claim that all important points on the coast should be connected with life-saving stations. His hon. friend asked in his motion for the appointment of a Commission to inquire into the desirability of connecting outlying lights with the shore. That was not so easy a matter. He argued from a return he had got from foreign countries in which such connection had been tried—every device had been tried; but one after the other the cables had all been destroyed by rubbing against the rocks. Her Majesty's Government were happy to assent to the motion of his hon. friend, and he earnestly hoped that they would be able to do something to save our fellow-countrymen in future years from the sad fate which had befallen so many in the past.

The motion was agreed to.

LEGAL INTELLIGENCE.

The English and Scottish Investment Company v. Brunton.

Judgment in this action was delivered by Mr. Justice Charles on Tuesday last. The case was argued some time back before his lordship, when judgment was reserved. It was an interpleader issue to try the right to a sum of money claimed by both parties in the following circumstances:—The Electrical Engineering Corporation (Limited) carried on business in premises at West Drayton. These premises they insured with the Sun Fire Office, and a fire having occurred in January, 1891, a sum of over £1,809 was admitted to be due, in respect of the said fire, to them. The Corporation prior to the insurance had created and issued debentures which gave a floating charge over the whole undertaking, and contained a clause under which the Corporation undertook not to mortgage or charge any part of their property so as to give priority over the debentureholder. The fire having occurred the Corporation were in need of money, and applied to the plaintiff Company for an advance on the security of the moneys payable by the Sun Insurance Office. The money was advanced under the circumstances as found by the learned Judge's judgment, and the question was whether the plaintiffs were affected by constructive notice of the existence of the condition in the debenture prohibiting the creation of prior mortgages and charges.

His LORDSHIP delivered a written judgment, going fully into the particulars of the flotation of the Electrical Engineering Corporation, quoting largely from the Articles of Association, and setting out the particular form of the debenture certificate. He said that the case involved some difficult and intricate points, and in the result found for the plaintiffs with costs. A very full report of the judgment, which had no technical interest for readers of *The Electrician*, appeared in *The Times* of Wednesday.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).

The following report of the Directors of this Company will be presented to the fifth ordinary general meeting, to be held on Friday, the 6th May, at Winchester House, E.C., at 12 o'clock:—

During the year the Company has been steadily extending its system of underground cables, and, except in certain of the outlying portions of the Company's areas, all the more important thoroughfares are provided with mains. The Directors are pleased to report that all the Company's stations have worked satisfactorily. The generating station for the Paddington district, which has been in course of construction during the past few months, will be completed almost immediately.

The expenditure upon works of construction during the year has been £113,583, making a total capital expenditure to the 31st December, 1891, of £486,926. This practically absorbs the Company's capital. Additional capital is required for the completion and equipment of the Paddington installation, supplying a wealthy and important district, which the Company has been successful in securing since its incorporation. Provision may also have to be made for certain street lighting, and other contemplated extensions of supply. The Board propose to meet the outlay for these purposes by a debenture issue not exceeding £100,000. The terms of such issue are now under the consideration of the Board, and the debentures will be offered in the first instance to the shareholders.

The gross revenue for the year amounted to £43,747. 1s. 3d., including a sum of £3,027. 1s. 3d. paid by the contractors on account of expenditure incurred by the Company in working the Sardinia-street, Rathbone-place, and Manchester-square installations during the time of testing, &c. The net revenue for the year was £9,719. 19. 8d., which enables the Directors to recommend a further final dividend of 2s. per share.

The Company's lamp connection, which on the 1st January, 1891, was equivalent to 48,000 8 candle-power lamps, rose during the year to 82,000 lamps. It now amounts to 96,000 lamps, and continues steadily to increase. With this increase the percentage of net profit may be expected to grow rapidly, as there will be no corresponding increase in the fixed charges.

It is with much regret that the Board have to record the death of their colleague, Alderman Sir R. N. Fowler, Bart., M.P. The vacancy thus caused has been filled up by the appointment of Admiral of the Fleet Lord John Hay, G.C.B.

In accordance with the Articles of Association, the following Directors, viz.:—J. Denison Pender, Esq., Admiral Sir George H. Richards, K.C.B., and John Benjamin Verity, Esq., retire from the Board, and, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., retire, and offer themselves for re-election.

CORRESPONDENCE.

AURORA BOREALIS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have not noticed any description in the daily papers of a most remarkable display of Aurora Borealis which I witnessed on the evening of Monday, 25th instant, when walking back from a concert in Chesterfield. On coming out I observed the sky very light, and thought at first this was due to the neighbouring blast furnaces; but on getting clear of the houses, so as to see the surrounding country, I found this was not the case. About ten o'clock and lasting for about fifteen minutes, there was a complete halo, about 25° from the horizon, and from this branched long streamers remarkably distinct, clearly defined, reaching up to the zenith, and covering a sector of about 45°. Towards the east these streamers had a reddish tinge. The distinctness of the streamers gradually died down, though one in the west remained clearly outlined after the rest had merged into a general glow.

I was with a gentleman who has travelled both on sea and land a great deal, and he said he had seen as good a display in northern latitudes, but never in his life in this country.

On speaking, about 10.40 p.m., through a telephone connected by a country line, there was evidence of electrical disturbance, shown by a continuous sharp crackling in the receiver.—I am, yours, &c., LLEWELYN B. ATKINSON.

Glasgow, April 27th.

[Judging by letters which have since appeared in the daily papers the Aurora Borealis must have been visible over the greater part of the United Kingdom. We can at any rate vouch for its appearance in the north of London, and at about 9·45 the sky in the direction of Hampstead Heath looked very much as if the light of a powerful projector was being directed to the zenith. After this the glow soon died away and was scarcely discoverable at 10 p.m.—ED. *E.*]

THE ELECTRIC LIGHTING OF PRETORIA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been drawn to your issue of February 26th last, in which you state that Messrs. Woodhouse and Rawson United, Limited, have "also prepared the plans and specifications for the lighting of Pretoria, and supervised the erection of buildings and machinery &c.;" and I am instructed to inform you that Mr. Cousens, who, I believe, is Messrs. Woodhouse and Rawson's agent in South Africa, was at first only employed by this Company in his private capacity, as consulting engineer, but ceased to hold that position some months ago. The plans and specifications necessary for the low-tension system adopted were prepared by Messrs. Crompton and Co., Limited; and the whole contract, including the supply, delivery and erection of the plant and machinery at Pretoria, has been undertaken, and is being successfully executed by them. Please insert the above correction in your next issue.—I am, yours, &c.,

THE PRETORIA LIGHTING COMPANY, LIMITED,
London, April 26, A. Moir, London Secretary.

TRADE NOTES AND NOTICES.

TENDERS INVITED.—Tenders are invited by the Dublin Corporation for the supply and erection of wires, fittings, and sundries for the electric lighting of some of the civic buildings. Specifications may be obtained at the offices of the borough surveyor, City Hall, Dublin, and at the offices of the electrical engineer, Mr. E. Manville, 39, Victoria-street, London, S.W.; and tenders must be lodged with Mr. John Beveridge, Town Clerk, City Hall, Dublin, by five p.m. on May 10th.

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TENDERS INVITED.—The Corporation of Southampton invite tenders for electrically lighting the Corporation Baths, Western Shore. Specifications may be had and plans may be seen, and all further particulars obtained, upon application to Mr. J. G. O. Aldridge, electrical-engineer, 9, Victoria-street, Westminster, and 23, High-street, Southampton. Sealed tenders, endorsed "Electric Lighting —Baths," must be left at the Town Clerk's office by 2 p m. on May 16th. Further particulars appear in our advertising columns.

SALE BY AUCTION.—Messrs. Wheatley Kirk, Price and Goulty announce in our advertisement columns that they will sell by auction on May 17th and 18th, the valuable electrical machinery, plant and effects pertaining to the estate of Messrs. Nicholson and Jennings and others, including two 45-unit "Goolden" dynamos and "Willans" engines combined; 20 dynamos by Brush, Siemens, and Ferranti, and others; 9 transformers, two 75 H.P. vertical compound engines by Brush Company; two Babcock-Wilcox boilers, about 150 H.P. each; 160 arc lamps, 2,600 switches, 4,000 ceiling roses 10,000 fuses 2,500 glass shades and globes 7 H.P. vertical engine, instruments, lamps, belting, cable, street lamps, shafting, pulleys and numerous other effects.

CALEDONIAN TELEPHONE COMPANY (LIMITED).—Resolutions have been passed and confirmed at meetings of the Company that it be wound up; that Mr. William Barton, accountant, of Glasgow, be the liquidator; and that the sale of the business to the National Telephone Company (Limited) be confirmed.

DEED OF ASSIGNMENT.—A deed of assignment and composition for the benefit of creditors has been executed by John Herbert Hale, electrician, 25, Stephen-street, Bristol, and "Collingwood," Nottingham-road, Bishopstow, Bristol. The deed provides for the payment of a composition of 12s. 6d. in the pound, payable 5s. on May 11th 1892, 5s. on July 11th, and 2s. 6d. on January 11th, 1893, secured by a surety. The trustee under the deed is Mr. James Milne, chartered accountant, Albion Chambers, Bristol. The unsecured liabilities are returned at £876. 0s. 6d., and the net assets are estimated at £615. 14s. 3d.

BANKRUPTCY, &c.—Frederick George Williams, trading at Crown Point, Denton, as an electrical engineer, under the style of Kenyon and Co., has been adjudicated a bankrupt.

MESSRS. DE FERRANTI, PATIN AND CO.—This Company, with offices in Paris, which was formed to work in France and Belgium the various patents of Mr. S. Z. de Ferranti, is being wound up, it being, we understand, Mr. de Ferranti's intention to himself exploit his patents in France.

MESSRS. GOOLDEN, ATKINSON, AND BIGGE.—In consequence of the large number of orders received from the Continent for mining machinery, Messrs. Goolden, Atkinson, and Bigge have opened a Continental office at 39, Rue Henri Maus, Brussels. This office, which was opened early in April, is under the direction of M. Pierre Chévenet, from whom every information may be obtained with regard to the long-distance transmission of power, and the special coal-cutting and other machinery supplied by this firm.

ISLE OF MAN INTERNATIONAL EXHIBITION.—This Exhibition is to be held at Douglas from July to September this year, and is to be lighted throughout by electricity. Having in view the probability that the Exhibition will be the first of a series to be held in the same buildings, the promoters have determined to make the electric light installation a permanency. The contract is in the hands of the Brush Electrical Engineering Company (Limited), who undertake to have everything in readiness by July 4th.

COUNTRY HOUSE LIGHTING.—Messrs. Drake and Gorham are engaged in fitting up Viscount Cantelupe's new house at Bexhill with the electric light. The power is to be obtained from a gas engine placed in an adjacent farm.

PRIESTMAN'S OIL ENGINE.—Messrs. Priestman Brothers (Ltd.) are issuing illustrated particulars showing their oil engines adapted to many varieties of use, from the portable agricultural engine to the high-speed electric light engine used by the Victorian Government.

PERSONAL.—Mr. John Hamilton Ward having resigned the management of the Electrical Engineering Company of Ireland (Limited), was entertained by the chief officers of the Company at a farewell supper, held at the Grosvenor Hotel, on Saturday, the 23rd inst., to bid him good-bye, and express their appreciation of him, and of the cordial relations which always existed between himself and the staff.

——— Mr. A. A. Davis undertakes the duties of manager of the above Company, in addition to those of secretary, and Mr. Arthur Handley, A.I.E.E., lately assistant engineer, becomes assistant electrical manager.

CHICAGO EXHIBITION, 1893.—The Royal Commission (Society of Arts, Adelphi, London, W.C.) announce that NO CHARGE will be made for space in the British Section of the above Exhibition.

SMOKING CONCERT.—On Friday evening last a smoking concert was held by the staff of Messrs. W. T. Goolden and their friends, at the "Swallow," Swallow-street, Piccadilly. In the unavoidable absence of Mr. W. T. Goolden, the chair was taken by Mr. Llewelyn B. Atkinson. A large company was assembled, and a most enjoyable evening was spent.

COMPANIES' MEETINGS & REPORTS.

Indo-European Telegraph Company (Limited).

The twenty-fifth ordinary general meeting of the members of this Company took place on Wednesday, at Winchester House, Old Broad-street, under the presidency of Mr. J. Herbert Tritton.

The MANAGING DIRECTOR (Mr. W. S. Andrews) read the notice convening the meeting, and the common seal was affixed to the register of members. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I have to move that the report and accounts be received and adopted, and that the dividend mentioned therein be declared. In doing so I am glad to find that there is very little for me to comment upon, because prosperity does not call for commentaries, and the year just passed has, on the whole, been a favourable one for us. The receipts are increased by £2,891. 19s. 2d., and the number of words exchanged with India for the first time exceeds by 40,390 words the number of words exchanged before the reduction in the rates applied in 1886; although, as yet, the money earned is still less by £39,521 than it would have been had not the rate been reduced. The expenses are £61,108. 12s. 10d. on all accounts, and we are able to place £10,000 to the reserve fund, and to recommend the payment of a dividend which, with the interim dividend already paid, makes up 10 per cent. for the year. We carry forward £5,983. 15s. 4d., as against £4,168. 16s. 7d. last year. You will, perhaps, remember that at our last meeting I expressed to you my personal opinion, that the twelve months' trial, then proposed, of the reduced rates with Australia was not sufficient. Well, gentlemen, that has so turned out. We have not yet got accounts for one clear year's traffic, and it has been determined by all the parties to the agreement not to give the required notice of termination, and consequently it remains in force. As far as we can gather, the increase in the number of words sent is proving on the whole satisfactory; there is a falling-off in money receipts from messages under the reduced tariff, but that was to be expected, and the elasticity so far apparent in the business is promising. We have, of course, sustained a loss of South Russian traffic owing to the failure of the wheat trade, and the deeply to-be-regretted consequent famine. We have subscribed on behalf of the Company for the relief of the sufferers £500, which we have no doubt you will approve when it comes to be submitted at our next meeting, in the accounts for the current period. With Persia there has been increased telegraphic intercourse, by which we have benefited; and, on the whole, taking the complete range of the business, there is, as already stated, an improvement in the Company's affairs, which, I imagine, you will concur with me in finding satisfactory. The maintenance and working of the through lines of the Indian Government and of the Company continue to be perfectly satisfactory. I do not know that there is anything more to which I need advert. The best and most eloquent Chairman's speech that I know of is contained in the resolution which I am about to submit to the meeting, as follows:—

"*That the report and accounts now submitted be received and adopted, and that a dividend be and is hereby declared for the half-year ended December 31, 1891, of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 20s. per share, both free of income-tax, making in all 10 per cent. for the year.*"

Mr. H. WEAVER seconded the motion.

The CHAIRMAN: If there are any remarks to be made or any questions to be asked before I put the resolution, now is the time, otherwise I will put the resolution to the meeting.

No shareholder rising to address the meeting the resolution was put, and was unanimously carried.

The CHAIRMAN: I have now to state that in accordance with the provisions of the Articles of Association Mr. Weaver and Mr. Delbrück retire, and offer themselves for re-election; and I beg to propose that these gentlemen be re-elected Directors of the Company.

Major-General G. B. TREMENHEERE, R.E., seconded the motion, which was unanimously adopted.

The CHAIRMAN: I have now to state that Messrs. Kemp, Ford and Co., the auditors, retire, and they offer themselves for re-election. As the right of electing these gentlemen is on the other side of the table, perhaps some one will propose their re-appointment, if that is the pleasure of the meeting.

Mr. H. ST. LAWRENCE SMITH proposed, and Mr. STEVENSON seconded the re-election of Messrs. Kemp, Ford and Co., and the motion was unanimously agreed to.

The CHAIRMAN: That concludes our business, and I thank you for your attendance.

Mr. STEVENSON said he thought the least they could do before separating was to pass a vote of thanks to the Chairman and Directors for their able administration of the Company's affairs. He was sorry to see so small an attendance, but the Company being so successful he presumed that the shareholders had not thought it necessary to put in an appearance.

Mr. RICHARDSON seconded the motion, and expressed his satisfaction at seeing so few shareholders present.

The resolution was carried unanimously.

The CHAIRMAN: Gentlemen, on behalf of my colleagues and myself, I beg to tender you my thanks for the resolution you have just passed, and to assure you that our best efforts will be given to maintain the prosperity of this prosperous Company.

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The Oriental Telephone Company (Limited).

The twelfth ordinary annual general meeting of this Company was held on Wednesday last, Mr. William Addison presiding.

The SECRETARY (Mr. A. B. Chalmers) read the notice calling the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said: Gentlemen, in moving the adoption of the report and balance-sheet I am glad to be able to again report the continued progress of the business of the Company, although it is not as rapid as we could wish. The result of last year's working practically gives us a net income of about the same as the year before. The gross amount earned in rupees was in excess of the previous year, but owing to the low price of silver and consequent depreciation in exchange our net profits have not materially increased. Had the same rates ruled during the past as in the previous year we should have made some £500 more. The question of exchange is necessarily a very serious one for an Eastern Company, and as at present there seems little probability of any great advance in the value of silver, we must depend to a great extent upon increase of business to make up for the falling off in the value of the rupee. You will have seen from the report how we propose to deal with the amount of £11,169. 13s. 7d., the result of the year's business, including £2,250. 19s. 9d. brought forward from last year. The sum of £257. 0s. 4d. was incurred in legal and other incidental expenses by proceedings in the High Court of Chancery for the purpose of testing the correctness of the view the Directors took of the manner of declaration and distribution of the dividend. The decision of the Court was in favour of the Directors' action. However, since the issue of the report the Directors have received notice of appeal from the solicitor of the vendor shareholders against the decision of Mr. Justice Kekewich, and the meeting will understand that I cannot now make any remark upon the case. The next item of £1,466. 4s. 8d., in reduction of capital expenditure, we consider necessary and proper. We propose to add £3,000 to the reserve fund, bringing that fund up to £10,000, all invested in Consols, and consequently available at a moment's notice should any sudden emergency arise for its use. We do not think that any shareholder can object to such a sum being placed to reserve, as the whole of the reserve will not even then amount to 1s. per share on the uncalled capital of the Company. It has been the endeavour of the Board to accomplish two things, the one to arrange terms with the holders of the vendors' shares on a reasonable and equitable basis, and the other to abolish or greatly reduce the liability of 9s. on the ordinary shares upon which 11s. are paid. Difficulties hitherto insurmountable have presented themselves to hinder our endeavours, but we are yet in hopes of arriving at a satisfactory settlement. In the meantime we consider it prudent to add yearly to the reserve fund, so that, in the event of new business being undertaken, we can enter upon it without having to make a call on the shareholders. I need add nothing to what is contained in the report in reference to the Indian Companies. The Telephone Company of Egypt is still progressing, and pays its 6 per cent. on the preferred shares, the whole of which we practically hold. All the exchanges worked by your Company are kept in a state of efficiency. In respect to the shares held in subsidiary Companies by this Company, your Directors are of opinion that they are fully of the value assigned to them in the balance-sheet, viz., £91,937. 14s. 10d. In accordance with the resolution which was carried at the last general meeting that the Company's Memorandum of Association be altered so as to embrace "any business or manufacture relating to the generation, employment, or utilisation of electricity or magnetism or the apparatus connected therewith," application was made to the Court for permission, which was granted, provided the name of the Company were altered so as to show the enlarged powers of the Company; and a resolution that the name of the Company be changed to "The Oriental Telephone and Electric Company, Limited," will be submitted to this meeting. The Board wish it to be distinctly understood that although acquiring the new powers in view of the daily increasing uses to which electricity can be put, it is not their intention to rush into electrical business of a speculative or experimental character. In conclusion, I may mention that during the seven years the present Board has been in office, besides placing £10,000 to reserve fund, £10,099 has been written off in various ways and £2,750 invested in the purchase of debentures and shares in our subsidiary companies, whilst £15,050 has been paid in dividends exclusive of that we are recommending you to declare to-day. I beg now to move :—

"*That the Directors' report, together with the balance-sheet to December 31, 1891, be approved and adopted, and that a dividend at the rate of 2½ per cent., free of income-tax, for the year ended December 31, 1891, be declared on the paid-up capital of the Company.*"

Mr. B. ST. JOHN ACKERS seconded the resolution, which was carried.

Mr. ACKERS next moved :—

"*That William Addison, Esq., be re-elected a Director of the Company.*"

Commander HANNAY seconded.

The motion was carried unanimously.

The CHAIRMAN having briefly returned thanks, Mr. G. B, FROST moved, and Mr. LLOYD seconded :—

"*That Henry Grēwing, Esq., be re-elected a Director of the Company.*"

The motion was carried unanimously.

Mr. SPICER moved, and Commader HANNAY seconded :—

"*That Messrs. Deloitte, Dever, Griffiths, and Co. be re-elected auditors of the Company for the current year, and that their remuneration as such auditors be the sum of fifty guineas.*"

The motion was agreed to.

Mr. CHARLES CHESTON: Before proceeding with the special business, while I and the others have no objection to the declaration of a dividend, you will take me as protesting against the application of the dividend on the vendors' shares in the way it was applied last year, until the hearing of the appeal. I do not propose to make anything more than a protest on behalf of my clients.

The CHAIRMAN then moved, and Mr. B. ST. JOHN ACKERS seconded the following resolution :—

"*That the name of the Company be changed to* THE ORIENTAL TELEPHONE AND ELECTRIC COMPANY, LIMITED."

The motion was agreed to, and the proceedings terminated with a vote of thanks to the Chairman.

Elmore's French Patent Copper Depositing Company (Limited).

The first annual general meeting of the shareholders in this Company took place on the 22nd inst., under the presidency of Sir Richard J. Meade.

The notice convening the meeting having been taken as read,

The CHAIRMAN expressed regret that, through having a bad cold, he was unable to address them; but asked Major Jones (the Vice-Chairman) to read the remarks which he (the Chairman) had prepared. Major Jones, he added, was for many years employed in one of the most responsible departments under Messrs. Armstrong, and he had a special knowledge of manufactures of every description.

Major JONES then read the speech, in the course of which the Chairman stated:—I have much pleasure in appearing before you to-day to give you the results of our stewardship up to the end of December last, and to congratulate you on the result and future prospects of the policy which was inaugurated by your Directors, and approved by you, at the statutory general meeting, viz, that having satisfied ourselves as to the quality of the products made by the Elmore process, and the facility with which the same could be manufactured, we should follow no hesitating policy, but at once take the bold step of laying out our works on a scale commensurate with the importance of the industry. I am pleased to be able to state to you the success that this policy has attained. To-day we are in the unique position of having magnificent works already started—second to none in the world for the manufacture of this class of product—complete, and capable of turning out 300 tons a month, whilst with comparatively little outlay, and in a short space of time, we should be able to nearly double this output. Had it not been for the broad policy so strongly urged by M. Secrétan, who would not accept the general managership of the Company in France unless the works were commenced on what he calls a small, but what we call a large, scale, viz., for an output of 300 tons a month—had it not been for M. Secrétan's assurance that he was abundantly satisfied that the quality, cost, and facility of manufacture of articles under the Elmore process would turn out what he is now able to prove, we should not, at so early a stage, have taken the responsibility, which has until recently been a very great responsibility, of embarking your money in so large a factory, until we had actually been at work on a commercial scale. The responsibility we have undertaken is, however, amply compensated for by the satisfaction that we feel to-day in the successful carrying out of our policy. With regard to the accounts submitted with the Director's report, which is in your hands, these deal with capital expenditure, and there is little to say in reference to them, as they explain themselves. Some of the items will not appear in future years, whilst, with regard to the administration charges, these have naturally been heavy, as they include all charges under this head in connection with the erection of the works, which will not occur again. The expenditure in the experimental workshop at Paris has been most usefully applied to the training of engineers and workmen in the Elmore process while the factory was being erected, so as to ensure their being fit for their duties on its completion, and also to the working out all special requirements of the French trade, which has enabled us to deliver the goods in demand directly we commenced manufacturing. He afterwards referred to the proposed increase of capital, respecting which he said that the Directors recommended that the increase should consist of 100,000 shares of £2 each, of which 60,000 should now be issued as preference shares entitled to 10 per cent. dividend. No more than 60,000 shares would now be issued, and no further capital would be issued until they had proved by the actual earning of profits that the employment of this capital was advisable. M. Secrétan showed, he added, that the increased profit which would result from the employment of the further capital would be very large and out of all proportion to the additional outlay, and the cost of production would be reduced.

The CHAIRMAN then moved the following resolution :—

"*That the Directors' report and balance-sheet for the period commencing from the date of the Company's formation, viz., September 10, 1890, to December 31, 1891, now submitted to the meeting, be, and are, approved and adopted.*"

M. SECRÉTAN, at the invitation of the Chairman, then addressed the meeting, observing that he still maintained the views he expressed in his recent report, which fully set out the position of the Company. They were now producing their manufactures in a perfectly industrial and commercial manner, and all that was required to increase the production was the additional capital referred to. They were now producing eight to nine tons a week, but this would be materially increased in two or three weeks.

Major JONES then seconded the motion. He spoke of the difficulties which had had to be encountered in establishing the factory, maintaining that these were inevitable; and afterwards expressed his confidence, as an expert, in the Elmore process.

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Mr. SIMPSON said that he could not help harking back to the circular of 1890, in which it was stated that they were to erect a 300-ton plant, and that £50,000 of debentures would be sufficient without calling on the shareholders again. They now, however, found that in addition to this £50,000, they were £50.000 in debt, and that there were liabilities on further contracts for unfinished work. They had heard a vast deal of what was to be, but they were still looking *in futuro* to the wonderful profits which were to come to them. He thought it would have been advisable to defer the issue of fresh capital until they had shown that they had earned a business profit.

Mr. HOLLAND also said that the shareholders could not live much longer on promises, and he desired some information as to whether the works were now paying.

Mr. WM. ELMORE, in answer to questions, made some encouraging statements relative to the working of the English Company and the Wire Company, stating that at the former the output was now from 15 to 18 tons a week, and that the profit on from two to three tons paid their expenses. The works of the Wire Company were now actually started. In regard to the operations at Dives, he thought that the samples on exhibition at the meeting spoke conclusively as to what was being done there.

Mr. GEDGE, M.P., asked why the French Company could not go on for a few weeks producing the manufactures without the issue of any further capital?

Mr. F. L. RAWSON considered that the position of the ordinary shareholders would be greatly improved by the new capital.

Mr. SCOTT, speaking as a consumer, testified to the value of the products.

Sir F. de WINTON (Chairman of the American Company), stated that the French works had been visited by one of the principal American copper brokers, who had written him a letter (which he read) stating that it seemed to him that M. Secrétan had proved the success of the Elmore process worked on a large scale.

The CHAIRMAN asked the shareholders to remember that the works at Dives had really only been one year in course of construction, and he thought that all present must allow that a vast deal had been done in bringing the factory to its present position.

The resolution was then carried; and the retiring Directors and auditors were afterwards re-elected.

On the motion of the CHAIRMAN, seconded by Major JONES, the resolution for raising the additional capital was passed, an amendment being accepted for enabling the Directors—if there were no legal objections—somewhat to modify the terms suggested in the resolution.

The usual complimentary votes closed the meeting.

The Directors' report adopted at the above meeting stated that the accompanying accounts were for the period from the date of the Company's formation on September 6, 1890, up to December 31, 1891, and that they dealt only with capital expenditure, no trading having been carried on. They showed the outlay that had been incurred on the Company's factory at Dives, including the purchase of raw material, copper, coal, &c., and in the preliminary experiments and arrangements for the commencement of manufacture. A circular explaining the reasons for the proposed increase of capital, together with a translation of M. Secrétan's report as General Manager, accompanied the Directors' report.

Sixty thousand of the new shares were placed upon the market during the week, 40,000 being reserved for allotment to existing shareholders and 20,000 offered to the public, the list of subscriptions closing yesterday (Thursday). This brings the total capital issued of the French Elmore Company to £320,000. The authorised capital is now £400,000.

Brazilian Submarine Telegraph Company (Limited).

The following is the Report of the Directors for the half year ended December 31, 1891, to be submitted to the thirty-seventh ordinary general meeting, to be held at Winchester House, Old Broad-street, E.C., on May 4th, at 12 noon :—

The revenue for the period amounted to £127,085 17s. 6d., and the working expenses to £32,496 2s. After providing £12,880 for debenture interest and sinking funds, and £1,037 7s. 4d., for income tax, there remains a balance of £80.682 8s. 2d.; to this is added £28.210 16s. 9d. brought forward from June 30th last, making a total of £108,693 4s. 11d. First and second interim dividends amounting to £39,000 have been paid, and £50,000 transferred to the reserve fund, leaving the sum of £19,893 4s. 11d. to be carried to the next account. The receipts for the half-year include the sum of £1,500 dividend to June 30, 1891, on the Company's shares in the African Direct Telegraph Company (Limited).

In accordance with the provisions for repayment of the first issue of debentures, dated July 31, 1884, 163 bonds representing £16,800 were drawn on the 11th inst., for payment at par on July 30th next. This, with the various drawings, will make a total repayment of £113,600, leaving £36,400 of the first issue of debentures outstanding.

The St. Vincent shore ends of the 1874 cables having become greatly worn by friction on the beach, they were renewed by the s.s. "Mirror" in October last. An interruption occurred on the 30th ult. in the 1874 cable of the St. Vincent-Pernambuco section near St. Vincent, arrangements were at once made for sending the s.s. "Mirror" from Gibraltar, and the repair was effected on the 9th instant.

The Duplex system of working has been satisfactorily established on the Lisbon-Madeira cable laid in 1882, and upon the Madeira St. Vincent and St. Vincent-Pernambuco cables laid in 1884, thus very materially increasing the carrying capacity of the Company's line.

The various sections of the Company's line are in good working order.

Submarine Cables Trust.

The following is the report of the Trustees, to be presented to the twenty-first ordinary annual meeting of the certificate holders, to be held at the offices of the Trust, 50, Old Broad-street, E.C., on Thursday, May 5th, at 12:30 :—

The revenue for this period, including the balance of £2,636. 15s. 9d. brought from the previous accounts, amounted to £25,436. 1s. 6d. During the past year the following coupons have been met :—

Due.	*Paid.*
April 15, 1891	£1 on account, May 15, 1891. £2 balance, October 15, 1891.
October 15, 1891.....	£3 paid, March 15, 1892.
April 15, 1892	£1. 2s. 6d., payable April 16, 1892.

The expenses of the Trust amounted to £1,186. 15s. 9d., and the payments on account of the coupons to £24,089. 12s. 6d., together £25,276. 8s. 3d., leaving a balance of £159. 13s. 3d. to be carried forward.

A table showing the original and present investments of the Trust is appended to the Trustees' report, showing that the investments remain unchanged since last year. Telegraph securities have maintained their value.

It is with regret the Trustees have to record the death of their secretary, Mr. Lewis Wells. They have appointed as his successor Mr. William Payton.

The meeting will have to elect two auditors for the current year, and Mr. John G. Griffiths and Mr. John Gane offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

[*In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in* "THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK, 1892, pages 308-322, *&c., &c.*]

SOHO ROLLING MILLS AND METAL WORKS COMPANY (LIMITED).—This Company was registered on April 16, 1892, with a capital of £35,000, in £1 shares, to acquire, take over as a going concern, and carry on in all its branches, the business of metal rollers, wire drawers, tube manufacturers, dealers, and merchants, carried on by William Wilkinson at the Soho Rolling Mills and other premises, situate in Heath-street South, in the City of Birmingham.

CAMBRIDGE UNIVERSITY AND TOWN ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above-named Company, made up to December 31, 1891, was filed on March 5th. The Company was registered on June 28, 1889, with a capital of £50,000, in £5 shares. At the time of making up, 8 shares had been taken, but no calls have as yet been made. No agreements have been filed.

HALIFAX AND BERMUDAS CABLE COMPANY (LIMITED).—The annual return of the above-named Company, made up to October 14, 1891, was filed on March 1st. The Company was registered on May 22, 1889, with a capital of £50,000, in £5 shares. At the time of making up, all the shares had been taken up, the full amount called, and all calls paid. (Note.—The above-mentioned return states that the whole capital has been issued as fully-paid, while the preceding returns state that the capital has been all taken up, the full amounts called, and all calls paid.)

IRISH HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—The annual return of the above-named Company, made up to December 31, 1891, was filed on March 15th. No general meeting was held in 1891. The Company was registered on June 26, 1889, with a capital of £100,000, divided into 19,900 ordinary and 100 founders' shares of £5 each. At the time of making up, 527 ordinary shares had been taken up, and upon each of these 10s. had been called, resulting in the payment of £202, and leaving £61. 10s. in arrear.

ISLINGTON AND GENERAL ELECTRIC SUPPLY, LIMITED (late the CAMBERWELL AND ISLINGTON ELECTRIC LIGHT AND POWER SUPPLY, LIMITED).—At an extraordinary general meeting of the Camberwell and Islington Electric Light and Power Supply (Limited), held at 17, Throgmorton-avenue, E.C., on Monday, Feb. 15 last, the following special resolutions were passed, and at a subsequent extraordinary general meeting held at the same place on Tuesday, March 1st, were confirmed :—(1) "That the name of the Company be changed to the Islington and General Electric Supply (Limited)." (2) "That the capital of the Company be reduced by cancelling the 100 founders' shares of £1 each." (3) "That the ordinary shares in the capital of the Company be consolidated in such manner that five thereof shall constitute one £5 share. (4) That the existing Articles of Association of the Company be and they are hereby repealed; and that the Articles, a copy whereof is now produced and signed by the Chairman of this meeting, be and they are hereby adopted, as the Articles of Association of the Company filed March 14, 1892). In the new Articles of Association, which were filed with the above, the number of Directors is stated to be not less than three nor more than seven. The first Directors are to be the persons appointed to the signatories to the Memorandum of Association, qualification £500. The form for the conversion of the 900 ordinary shares, of £1 each, into 180 ordinary shares, of £5 each, was also filed on March 14th. A notice, signifying the approval of the Board of Trade to the above

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change of name, was filed on March 21, 1892. At an extraordinary general meeting, held at 17, Throgmorton-avenue, on Friday, April 1, 1892, a special resolution was passed, and subsequently confirmed, altering Article 79 by the substitution of 200 for 500, filed on April 23, 1892. The above-named Company was registered on June 28, 1890, with a capital of £1,000, divided into 900 ordinary and 100 founders' shares of £1 each. At the date of the last return (made up to January 4, 1892, and filed January 18th) only seven founders' shares were taken up, the original signatories being the only shareholders.

KENSINGTON COURT ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 31, 1892, was filed on the 6th inst. The Company was registered on June 5, 1886. At the time of making-up, all the shares had been taken up, the full amount called and all calls paid.

KEYS' ELECTRIC COMPANY (LIMITED).—The annual return of the above-named Company, made up to December 31, 1891, was filed on March 16th. The Company was registered on March 7, 1890, with a capital of £15,600, divided into 3,000 ordinary shares of £5 each, and 600 founders' shares of £1 each. At the time of making up all the shares had been taken up, and upon 2,700 of the ordinary shares £3. 15s. per share had been called, while upon the remaining 300 ordinary and 600 founders' shares the full amount had been called. All the calls have been paid, amounting in all to £12,225.

LAING ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of the above-named Company, made up to February 15, 1892, was filed on February 17th. The Company was registered on January 7, 1882, with a capital of £1,000.000, in £10 shares. At an extraordinary general meeting of the Company held on August 3, 1882, certain resolutions were passed, and at a subsequent meeting held on September 4, 1882, were confirmed, to the effect that the offer made for the purchase of the goodwill, patents, and all other rights and interests of the Anglo-Colonial Electric Light Company (Limited), and also all its machinery, implements, &c., for the sum of £45,000, to be paid for by fully-paid shares in the above-named Company, should be accepted, and that a similar offer for the purchase of the goodwill, patents, rights, interests, and effects of the Anglo-Colonial Electric Light Company (Limited), for the sum of £75,000, to be satisfied in a similar way should also be accepted, and agreements have been entered into to that effect. At the time of making-up, 12,007 shares had been taken up, of which 12,000 have been issued as fully-paid in accordance with the mentioned resolutions. Upon the remaining shares, the full amount has been called, but nothing has been paid.

LONDON ELECTRIC SUPPLY CORPORATION (LIMITED).—The annual return of the above-named Company, made up to April 8, 1892, was filed on April 20, 1892. The Company was registered on August 26, 1887, with a capital of £1.000,000, in £5 shares. By special resolution dated December 21, 1888, the capital was raised to £1,250.000 by the creation of 50.000 preference shares of £5 each. At the time of making up 111.000 ordinary and 49.840 preference shares had been taken up. Upon all of these the full amount has been called, resulting in the payment (including £160 paid on 160 forfeited shares) of £798,630, leaving £5,730 as yet unpaid.

NOTTINGHAM ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of the above-named Company, made up to January 4, 1892, was filed on March 4th following. The Company was registered on February 27, 1889, with a capital of £100,000, in £10 shares, of which 100 were founders' and 9,900 ordinary shares. At the time of making up, 27 founders' and 200 ordinary shares had been taken up, but no calls had been made. There are 10 shareholders, each of whom hold 20 ordinary shares and from two to four founders'. They are also the original signatories to the memorandum and articles of association. No agreement for the acquisition of contracts, plant, businesses, &c., have been filed.

PONTYPRIDD ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of the above-named Company, made up to March 28, 1892, was filed on the 23rd inst. The Company was registered on April 30, 1892, with a capital of £10,000, in £5 shares. At the time of making-up, 7 shares had been taken up, but no calls have been made.

TAYLER SMITH ELECTRIC COMPANY (LIMITED).—The statutory return of the above-named Company, made up to November 5, 1891, was filed on March 10, 1892. The Company was registered on July 21, 1891, with a capital of £6,000, divided into 300 £6 per cent. preference and 300 ordinary shares of £10 each. At the time of making up, 259 preference and 300 ordinary shares had been taken up, and all the ordinary shares had been issued as fully paid, in full satisfaction of the purchase price. Upon the remaining 259 preference shares £2. 10s. per share had been called, resulting in the payment of £647. 10s. In addition to this £610 has been paid in anticipation of calls, making a total of £1,257. 10s. paid.

TELEPHONE COMPANY OF EGYPT (LIMITED).—The annual return of the above-named Company, made up to the 19th inst., was filed on the 23rd. The Company was registered on January 30, 1883, with a capital of £100,000, divided into 16,000 preferred shares and 4,000 deferred shares of £5 each. At the time of making up, 12,071 preferred and 4,000 deferred shares had been taken up, of which 12,000 preferred and the deferred shares had been issued as fully paid in accordance with the above agreement. Upon the remaining 71 shares the full amounts have been called, resulting in the payment of £355.

WYNNE'S ELECTRIC CLOSED TUBE TRAMWAYS (LIMITED).—The annual return of the above-named Company, made up to March 12, 1889, was filed on the 4th inst. The Company was registered on July 28, 1887, with a capital of £6,000, in £100 shares, to purchase or otherwise acquire the letters patent or patent rights and privileges granted, or to be granted, to Frank Wynne, of 5, Westminster-chambers, Victoria-street, Westminster, S.W., for inventions relating to the application of electricity to the propulsion of vehicles or tramways, railways and roads, and to develop and turn to account the same. The patents sold to the Company were No. 1791, of 1883, for the United Kingdom, and No. 324,447, for the United States of America; and the following had been applied for at the time of registration:—Nos. 9,215 and 15,671, of 1886, and No. 747, of 1887, for the United Kingdom, with their corresponding patents applied for in Germany, France, and the United States. At the time of making-up (March 12, 1889), 47 of the 60 shares had been taken up, of which 32 had been issued as fully-paid in part payment of the purchase consideration. Upon the remaining shares the full amount had been called, resulting in the payment of £1,430, and leaving £70 as yet unpaid. Another annual return, made up to September 1, 1891, was also filed on the 25th inst., when the shares taken up, the calls paid, calls unpaid, and also the shareholders were exactly the same as in the preceding return. The latest annual return, made up to the 12th inst., was filed on the 25th inst. Fifty-two shares had been taken up, of which 32 had been issued as fully-paid. Upon 15 of the remaining shares the full amount had been called, and upon the remaining five shares £75 per share had been called, resulting in the payment of £1,805, and leaving £10 as yet unpaid.

CITY NOTES, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic receipts for the week ended April 24th were £807, as against £784 for the corresponding period of last year, being an increase of £23. The total receipts to date, from January 1st last, amount to £13,624, against £12,514 in the corresponding period of 1891, being an increase of £1,110.

JOHANNESBURG LIGHTING COMPANY (LIMITED).—Subscriptions are invited for an issue of Seven per Cent. Mortgage Debentures of the Johannesburg Lighting Company (Limited), in bonds of £50 each. The present forms part of an authorised issue of £60.000, convertible, at the option of the holders, into ordinary shares of the Company, the bonds being repayable at par on December 31, 1901. The Company's share capital is £150,000, and the debentures are secured by a trust deed constituting a first charge on the Company's property and undertaking, the interest being payable half-yearly. Two concessions have been acquired from the Government for supplying gas and electric power in the city of Johannesburg; the term for each is 99 years. Applications should be forwarded to the African Banking Corporation, 43, Threadneedle-street, E.C., not later than Saturday next.

MADRAS ELECTRIC TRAMWAYS COMPANY (LIMITED).—The prospectus has been issued of this Company, the capital of which is £100,000, in £1 shares, payable 2s. 6d. per share on application, 2s. 6d. on allotment, the remainder being called up as required, with 28 days' notice. Shares subscribed for in India at Rs. 15 each. The objects of the Company were described in *The Electrician* of April 8th. The list of applications opened on Wednesday, and will close on Wednesday next, at 4 p.m.

SOUTH AMERICAN CABLE COMPANY (LIMITED).—In our advertisement pages will be found the prospectus of the above Company, which has been incorporated with an authorised share capital of £500.000, divided into 50,000 shares of £10 each. The present issue is for £300,000, in £10 shares, of which £100.000 will be taken by the contractors for the work to be done, leaving £200,000 of the ordinary share capital now offered for subscription. There is also offered £300,000 in Five per Cent. Mortgage Debentures of £100 each, the price of issue being £94 per cent., redeemable at par by 25 annual drawings, beginning in 1895; interest being payable on June 30th and December 31st. These debentures are secured by a First Mortgage Trust Deed over the cables and property of the Company. The object of the Company is to complete an additional telegraphic route between Europe and South America; the map accompanying the prospectus showing the chief points of connection which the cable is intended to effect. The Company's cables will be laid, under concessions from the Brazilian and French Governments, between Penambuco, in Brazil, and St. Louis, in Senegal, touching at the island of Fernando de Noronha. The term of the Brazilian concession, so far as exclusive rights are concerned, is for 25 years, after which the Company has the privilege of continuing the service subject to the right of purchase by the Government. The French concession confers permanent landing rights in Senegal for the purpose of telegraphic communication with Brazil, and enables the Company to join its cables at Senegal with those of the Spanish National Submarine Telegraph Company now laid between Senegal and the Canary Islands and between the Canary Islands and Cadiz. As Cadiz is a station of the international land wire system and of the submarine system of the Eastern Telegraph Company, the new line will thus form a direct connection between the telegraphs of South America and those of Europe and the rest of the world. The prospectus sets out particulars of the volume of cable traffic with South America, a share of which the Directors of the new Company anticipate securing, and the revenue from the various sources is expected to be not less than £85,000 a year, and, after deducting £49,000 for estimated working expenses, repairs, debenture interest, &c., it is anticipated that a sufficient balance will remain to pay 10 per cent. on the present issue of share capital. The India Rubber, Gutta Percha, and Telegraph Works Company (Limited) have contracted to lay suitable cables, and to supply all the necessary working and testing instruments, and to hand over to the new Company the Brazilian concession for the sum of £520,000, of which the above sum of £100,000 in fully paid shares forms part of the payment. Applications will be received by the National Bank of Scotland, Nicholas-lane, Lombard-street, E.C. (and at Edinburgh and all its branches), the

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bankers to the Company; or by Messrs. M'Nicoll and Rogers, the brokers; or at the offices of the Company, 106, Cannon-street, E.C. On the ordinary shares £1 per share is to be paid on application, 30s. on allotment, and three payments of £2. 10s. each on May 16th, June 16th, and July 16th respectively. On the debenture issue, 10 per cent. on application, 10 per cent. on allotment, 30 per cent. on May 16th, and 44 per cent. on June 16th. The contractors guarantee the payment of the interest on the debentures until the cables are in operation. The trustees for the debenture holders are Messrs. James Robertson and Thomas Ness, Manager and Assistant-Manager of the Bank of Scotland, and an influential Board of Directors include Sir Charles Tupper, Bart., G.C.M.G., C.B.; the Hon. Henry Marsham; Sir Henry C. Mance, C.I.E., M.Inst.C.E.; John Y. Buchanan, Esq., F.R.S.; Robert Kaye Gray, Esq., M.Inst.C.E. The engineers to the Company are Messrs. Clark, Forde, and Taylor, and the secretary is Mr. J. Frayssinier. The lists of applications will be closed on Tuesday next, May 3rd, for both London and the country.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have decided to recommend dividends for the six months ended December 31st last, as follows:—6s. per share on the First and Second Preference shares and 6d. per share on the Ordinary shares. The sum of £2,123 is carried forward.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—**The traffic receipts for the week** ended April 22, 1892, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,516.

COMPANIES' SHARE LIST.

Present Amount	Amount of Share.	Last Dividend.	Name.	Previous Week's Price. April 20.		Price Wednesday, April 27.		Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business done during week ending April 27. Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12 6	Anglo-American	43½	49½	48½	49½	5 6 1	Jan., Apr., July, Oct	49½	..
£2,849,51	Stock	25 0	Do. Preferred	87½	88½	87½	88½	5 17 4	" "	8[illegible]	87⅞
£2,849,510	Stock	5/0	Do. Deferred	11	11⅛	11	11⅛	..	" "	11[illegible]	1[illegible]
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100	103	100	103	3 17 8	January and July	..	..
180,000	£10	3/0	Brazilian Submarine	10⅞	11⅛	11	11⅛	6 19 2	Mar., June, Oct., Dec	11[illegible]	11⅛
£68,200	£100	5%	Do. 5 per Cent. Bonds	100	103	100	103	4 17 1	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	155	160	155	160	4 7 6	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	10½	11⅛	10½	11⅛	6 19 2	February and August	11[illegible]	..
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	..	..
12,931	5	1/7	Direct Spanish (£4 paid)	3½	3⅝	3½	3⅝	6 18 8	April and October	3½	..
6,000	5	10%	Do. Preference 10%	8½	9½	8½	9½	5 5 3	" "	..	..
60,710	20	3/6	Direct United States	11½	11⅝	11⅝	11⅝	6 0 2	Jan., Apr., July, Oct	11⅝	11½
400,000	10	2/6	Eastern	14⅝	14½	14⅝	14½	4 10 5	" "	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15½	15½
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	109	112	109	112	3 11 5	May and November	112	111
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	15	15½	15	15½	4 11 10	Jan., Apr., July, Oct.	15½	15[illegible]
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	108	111	108	111	3 12 1	February & August	109½	109
£78,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	102	106	102	106	4 15 3	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	102	106	102	105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99	102	99	102	3 18 5	February & August	100½	..
180,227	10	2 6	Globe Telegraph and Trust	10	10½	10	10½	5 2 5	Jan., Apr., July, Oct.	10½	10
180,042	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 18 8	" "	15⅜	15
160,000	10	5/0	Great Northern	18⅜	19½	19	19½	4 7 2	Jan., April, and July	18½	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	106	109	4 11 9	March & September	..	..
17,000	25	12/6	Indo-European	41	43	41	43	5 16 8	May and November	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 8 7	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 0 1	March & September	..	..
9,000	8	4/0	Reuter's	6	7	5½	6½	6 3 1	April and October	5[illegible]	..
3,331	£100 Cert.	2½/6	Submarine Cables Trust 6%	115	120	115	120	5 0 0	" "	115½	..
15,609	10	3/0	West African Telegraph	7	8	7	8	6 5 0	January and July	..	..
£271,400	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	..	..
30,000	10	2.0	West Coast of America	2½	3½	2½	3½	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	102	106	102	106	7 10 11	June and December	106	..
88,321	10	1/0	West India and Panama	1⅜	1⅞	1⅜	1⅞	..	" "	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10½	10
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
67,007	15	6/0	Western and Brazilian	10	10½	9⅞	10½	7 6 6	" "	10⅜	9⅞
30,364	7½	6/0	Do 5 per Cent. Cumulative Preferred	6	6½	6	6½	5 15 3	" "	6⅝	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4	4½	3⅞	4½	..	" "	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104	107	105	108	5 11 1	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	104	107	105	108	5 11 1	" "	106½	105½
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	118	122	118	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	6 0 0	March & September	..	..
			TELEPHONES.								
224,850	14/0	4·094d.	Consolidated Telephone Const. & Maintenance	⅜	½	⅜	½	8 7 7	May and November	..	..
x20,000	£1	4·76d.	Oriental (11s. paid)	¼	⅜	¼	⅜	6 3 11	Yearly	..	..
433,984	5	2/6	National	4⅛	4⅜	4⅛	4⅜	6 9 9	June and December	4⅜	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12⅛	13½	12⅛	13½	4 8 11	" "	..	..
15,000	10	6%	Do 6% Cumulative 2nd Pref.	12	12⅛	12	12⅛	4 16 0	" "	12½	..
420,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd.)	107	109	106	108	4 3 4	January and July	107½	106⅜
58,000	5	1/0	United River Plate	2	3	2	3	..	" "	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
30,152	£10	..	City of London Electric Lighting (£8 paid)	7⅛	8	7⅛	8	..	—	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—	..	..
8,332	£5	..	House to House Electric	5⅛	5⅜	2⅜	3⅛	..	—	..	..
..	£5	..	Kensington & Knightsbridge Elec. Light (fully pd.	..	..	5⅝	6	..	..	..	..
..	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	5⅝	6	..	January and July	..	..
30,000	£5	4½%	Liverpool Electric Supply (£3 15s paid)	2⅜	3	3⅜	3⅝	..	March	..	..
10,000	£5	4½%	Do. (fully paid)	5	5⅛	5	5⅛	..	March	..	..
111,000	5	..	London Electric Supply	⅞	1⅛	⅞	1⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	8⅛	8⅜	8⅛	8⅜	..	..	8⅞	8⅛
6,318	10	..	Notting Hill Electric Lighting (fully paid)	4⅛	5⅛	4⅛	5⅛	—	..	4⅝	4⅛
18,680	£5	5/0	St. James' and Pall Mall	8⅛	8⅜	8⅛	8⅜	—	..	8⅝	8⅛
7,900	£5	7%	Do. 7% Preference	7⅛	8	7⅛	8	..	..	7⅛	7⅛
42,853	5	..	Westminster Electric Supply (fully paid)	6⅛	7	6⅛	7	..	..	6⅝	6½
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	1 9	Brush Electrical Engineering	3	3⅛	3	3⅛	..	..	3⅛	..
69,996	2	6%	Do. 6 per Cent. Preference	2	2⅛	2	2⅛	5 2 7	..	2⅛	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5⅛	5⅜	5⅛	5⅜	5 16 8	January and July	5⅜	..
17,130	5	17½	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	12/0	Electric Construction	5⅜	6⅛	5⅜	6⅛	..	—	6⅛	5⅛
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜	2⅝	2⅜	2⅝	—	—	2⅝	2⅜
20,000	5	..	Fowler-Waring Cables (fully paid)	2	3	2	3	..	..	..	..
41,600	10	15/0	India Rubber, Gutta Percha & c., Works	19½	20½	20	21	5 19 0	February & August	20⅜	20⅛
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	105	102	106	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	4⅛	5⅛	4⅛	5⅛	..	..	4⅛	..
11,334	£10	8/0	Do. Preference	8	9	8	9	8 13 0	December and June	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	6/0	8/0	6/0	8/0	..	..	..	..
78,949	5	5/7½	Swan United (£3. 10s. paid)	3⅜	4⅛	3⅜	4⅛	9 0 9	May and November	..	..
36,250	12	36/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 1	March and July	43⅜	42⅜
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July	..	..
—	£5	15%	Woodhouse and Rawson Ordinary (£2. 10s. paid)	..	..	⅜	⅝	..	..	..	—
—	£5	8%	Do. Preference (fully paid)	..	..	2⅜	3	..	—	—	—
			RAILWAYS AND TRAMWAYS.								
£9,750	10	7½%	Blackpool Electric Tramway	..	..	..	..	—	—	..	..
50,000	£10	—	City and South London Railway	2⅜	3⅜	2⅜	3⅜	..	—	..	..

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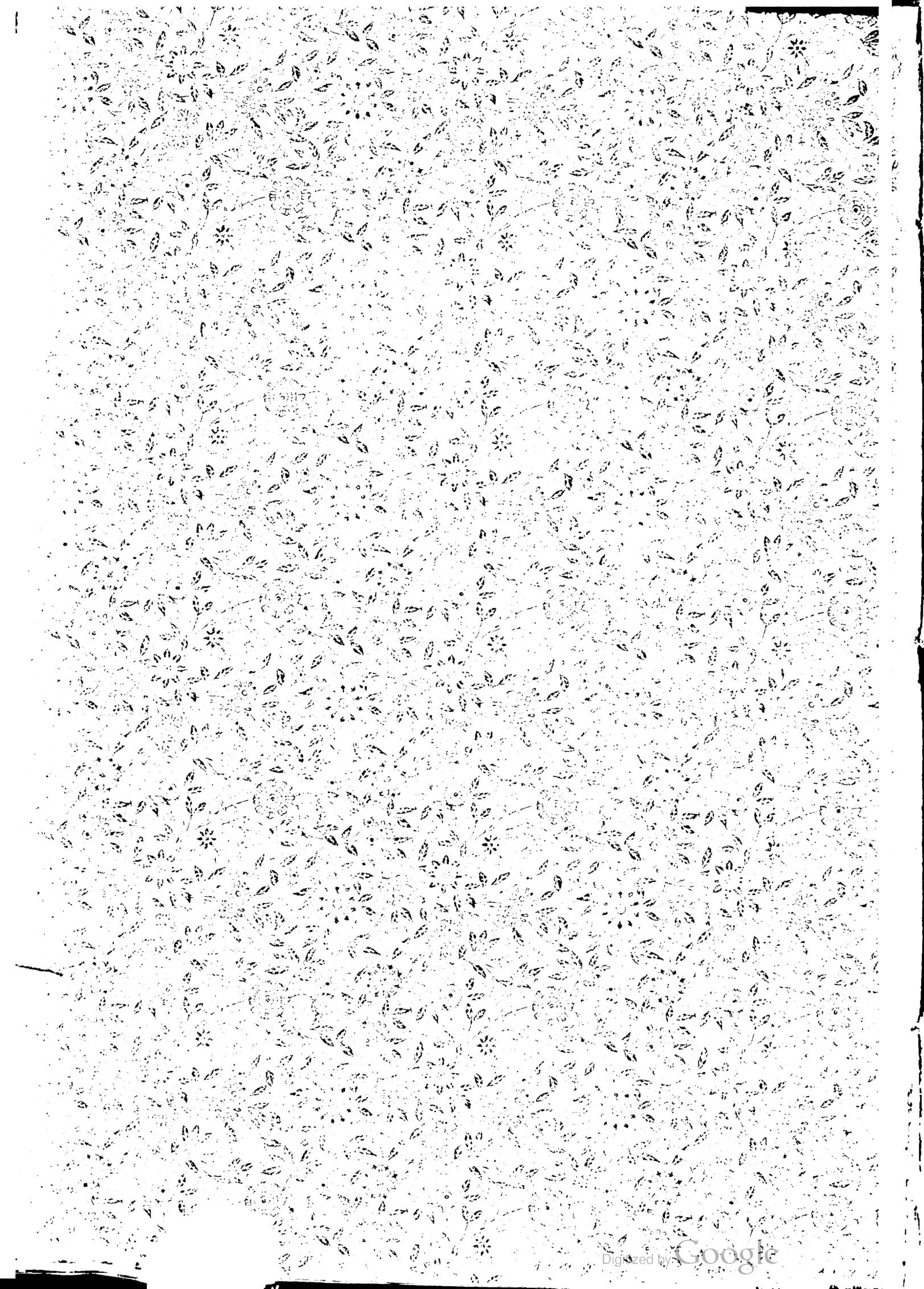
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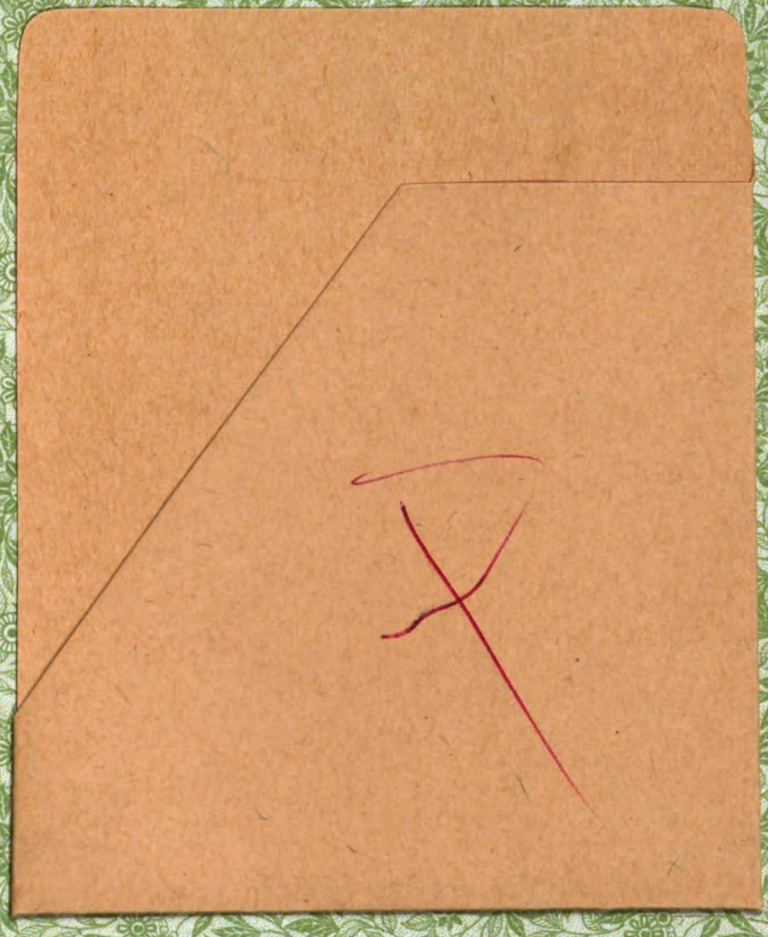

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